

MINISTRY OF NATURAL RESOURCES AND LOCAL GOVERNMENT



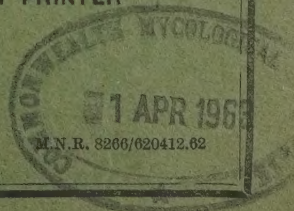
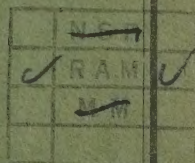
NYASALAND

Annual Report
of the
Department of Agriculture
for the
Year 1960/61
(PART II)

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DEPARTMENT OF AGRICULTURE

ANNUAL REPORT FOR THE YEAR 1960/61

(PART II)

C O N T E N T S	PAGE
Introduction	3
List of Experiment Stations and Staff List .. .	5
Ecology of Experiment Stations .. .	7
Maize .. .	28
Other Cereals .. .	36
Oil Seeds .. .	41
Other Legumes .. .	47
Tobacco .. .	50
Cotton .. .	65
Tea .. .	93
Tung .. .	140
Coffee .. .	144
Fruit and Vegetables .. .	159
Cocoa .. .	163
Pastures .. .	166
Rotation Experiments .. .	170
Mixed Farm Unit, Bvumbwe .. .	175
Chemical Weed Control .. .	180
Soil Physics and Irrigation .. .	182
Agricultural Chemistry .. .	196
Pathology .. .	199
Entomology .. .	205
Machinery for Smallholders .. .	208
Publications .. .	212

INTRODUCTION

Staff shortages continue to be a cause for anxiety and for this reason some sections have had to be omitted in this year's report. Maize breeding, for instance, has not made further headway, though it has been possible to maintain all the selected lines. On the other hand two new sections have been included for the first time, a section on the Ecology of Experiment Stations and some notes on machinery for smallholders. The first of these will not be a regular feature but can be used for reference so that readers can appreciate the environment in which the experiments have been conducted. The agro-ecological survey of the country has made excellent progress and sections dealing with the Northern and Central Provinces will be published shortly. It is hoped that further articles on small machinery will be published from time to time.

Further advances have been made in the study of the agronomy of maize and the results of more fertilizer trials together with work on various cultivation practices enable advice to be given on the best methods of obtaining the highest yield in the different parts of the country. The continued increase in groundnut production lends importance to the testing of varieties and several varieties new to Nyasaland have shown adaptation to different ecological zones. Previous work has demonstrated the advantage that groundnuts give to succeeding crops and the growing of increased areas is being actively encouraged. Rosette disease was not severe in the past season and though early planting and close spacing minimize the spread of the disease, there are certain conditions, not yet understood, when these preventive measures are quite ineffective.

In the work on tobacco the greatest importance is attached to quality. The proportion of heavy dark-fired leaf in the total crop produced has been decreasing for a number of years and does not now meet trade requirements. An extensive survey of the main growing area (reported under Agricultural Chemistry) revealed a more widespread shortage of phosphate than had been suspected. This is probably only one of the reasons and investigations are still proceeding. In Burley tobacco, on the other hand, the demand is for a greater proportion of light leaf suitable for cigarette manufacture and investigations into methods of producing this type of leaf are being made.

There was a record crop of tea and investigations (now in the hands of the Tea Association) into improved quality as well as yield continue. The higher prices for tung oil have revived interest in this crop though no new plantings were made during the year. The new clones now available have been shown to be consistently high yielders. The area under coffee is increasing slowly. The environment is not ideal for coffee growing and experiments have defined the various practices that must be followed if consistently high yields are to be obtained. The investigation into *Fusarium* disease continues and there is some hope that resistant or tolerant varieties may be found. The small cocoa plantings have made further progress and an experimental batch of chocolate was manufactured. There are difficulties yet to be overcome such as pod diseases and the small size of bean in the first crop was noticeable. There is hope that this may become a useful crop when large-scale irrigation becomes possible.

Investigations into irrigation and soil moisture use of crop continue. The long dry season makes water of great importance to perennial crops and the results of numerous experiments have increased our knowledge in this subject. Much use has been made of resistance blocks buried in the soil and the results of this work have given information on the best time to prune tea and the effect of shade trees planted among tea and coffee.

The cotton variety Albar has now been distributed throughout the country and testing of strains for increased jassid resistance and other factors continues. The work on cotton pests has resulted in finding a method of spraying that has been shown to give considerably increased yields and work is now proceeding to find a practicable way of introducing this on a large scale.

LIST OF EXPERIMENT STATIONS AND STAFF LIST

The experiment stations in operation during the period under review, and the officers who have been in residence, are listed below:

Agricultural Research Station, Chitedze, Box 158, Lilongwe

Senior Agricultural Research Officer	..	H. B. AMBROSE, B.SC. (AGRIC.) (LOND.), DIP. AGRIC. (CANTAB.)
Agricultural Officer (Tobacco)	..	H. ROSTRON, B.SC. (LEEDS), D.T.A. (TRIN.) D. E. EDMOND, B.SC. (LEEDS)
Agricultural Supervisor (Tobacco)	..	A. J. TALLACH, S.D.A., S.D.D.
Agricultural Officer (Agronomist)	..	P. BROWN, B.A. (CANTAB.), D.T.A (TRIN.)
Plant Breeder	.. ..	<i>Vacant</i>
Agricultural Chemist	..	R. A. WOOD, B.SC. (MANCH.)
Assistant Chemist	.. ..	W. D. CHONA, B.SC. (RHODES)
Farm Manager	.. ..	C. P. MIDDLEMISS, B.SC. (LOND.)

Bvumbwe Tung and Agricultural Experiment Station, Box 48, Limbe

Agricultural Officer	.. ..	L. J. FOSTER, B.SC. (READING)
Agricultural Chemist	..	C. V. CUTTING, B.SC. (LOND.), PH.D., A.R.I.C.
Plant Pathologist (Coffee Research)	..	M. A. SIDDIQI, M.SC. (ALIGARH), PH.D. (WALES)
Laboratory Technician	..	R. C. PEAK
Farm Manager	.. ..	E. FABIAN, N.D.A., S.D.A. F. HIGSON

Tuchila Experiment Station, Box 28, Luchenza

Officer in Charge		J. A. SEAGO, N.D.A., C.D.A.
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Makanga Experiment Station, P.O. Chiromo

Officer in Charge		A. B. HEARN, B.SC. (READING), DIP. AGRIC. (CANTAB.), D.T.A. J. W. GRAY, B. AGR. (BELFAST), D.T.A. (TRIN.)
Cotton Specialist (Seconded E.C.G.C.)	..	D. F. COLLINGS, C.D.A.
Farm Manager	.. ..	D. F. COLLINGS, C.D.A.

Mwera Hill Experiment Station, Box 11, Dowa

Officer in Charge I. K. MSISKA

Chitala Experiment Station, P.O. Salima

Officer in Charge Y. J. KAMPONDA

Mbawa Experiment Station, Box 11, Mzimba

Officer in Charge G. D. HORSPOOL, N.D.A., C.D.A.

Provincial Agricultural Officers

Southern Province, Box 32, Blantyre .. J. A. SANDYS, B.SC. (NOTTINGHAM)

Central Province, Box 92, Lilongwe .. J. EVANS, B.SC. (READING)

Northern Province, Box 13, Mzuzu .. R. J. HARVIE, B.SC. (ALBERTA),
D.T.A.

Headquarters, Box 87, Zomba

Chief Agricultural Research Officer .. S. T. HOYLE, O.B.E., M.A. (CANTAB.),
A.I.C.T.A.

Entomologist R. C. H. SWEENEY, M.I.BIOL., F.R.E.S.

Ecologist *Vacant*

Plant Pathologist D. C. M. CORBETT, B.SC. (HONS.)
(ABERD.), DIP. AGRIC. SC.
(CANTAB.), D.T.A. (TRIN.)

Soil Surveyor A. YOUNG, M.A. (CANTAB.), PH.D.
(SHEFFIELD)

Cotton Pest Research Scheme

Officer in Charge (Gatooma) .. J. P. TUNSTALL, B.SC. (HONS.), DIP.
AGRIC. (READING), A.R.C.S.

Entomologist (Gatooma) .. G. A. MATTHEWS, B.SC., A.R.C.S.,
F.R.E.S.

Technical Assistant (Gatooma) .. A. A. K. RHODES

ECOLOGY OF EXPERIMENT STATIONS

This survey gives a summary of the environmental conditions on the stations at which the principal experimental work of the Department of Agriculture is carried out. It is intended firstly to assist the reader outside Nyasaland in determining the extent to which the experimental results contained in this Report are applicable to conditions in other territories; and secondly, to show the areas in Nyasaland for which the experiment stations are representative, thereby indicating the degree to which the results are directly applicable, or may require to be interpreted with caution in view of differences in local conditions. The eight experiment stations of the Department are included, together with Mimosa Tea Research Station operated by the Tea Association of Nyasaland and Rhodesia. The location of these is shown in fig. 1. It should be noted that in addition to the work on these stations, a large number of controlled agronomic trials are carried out on the holdings of Agricultural Instructors, which cover a wide range of environmental conditions.

A brief account of the major factors in the physical geography of Nyasaland as a whole is given first; certain terms employed in the descriptions of stations are also defined in this section. This is followed by a treatment of the stations separately. For each station is given firstly, the location and the principal types of experimental work carried out; secondly, a short summary of the landforms, climate and vegetation; thirdly, a more detailed description of the soils; and fourthly, an indication of the areas for which conditions on the station are representative.

General Features of the Nyasaland Environment

LANDFORMS

Nyasaland lies along a sector of the African Rift Valley, between latitudes 9° and 18° south. The floor of this valley is occupied by Lake Nyasa in the north, and the Shire River, a tributary of the Zambezi, in the south. The majority of the country is drained towards this valley, the entire western border lying along the Luangwa/Shire watershed. There are five major relief units:

(i) *High-altitude Plateaux.* These lie principally above 5,500 ft., and have gently undulating landforms. The majority of them are not utilized for agriculture, due to low temperatures and poor soils, and there are no agricultural experiment stations sited on them. The principal areas are the Nyika, Vipya and Mlanje Plateaux; smaller remnants occur in the Misuku Hills, the Mafingi Hills, the Pirewombe Hills, the North Vipya, on Chongoni, Dedza, Chirobwe, Zomba, and Chiradzulu Mountains, and in the Kirk Range.

(ii) *High-altitude Hill Areas.* These include the scarp zones of the previous unit, together with hilly and moderately undulating land lying at altitudes of 4,000–6,000 ft. The principal areas are the Ruwenga Hills north-west of Fort Hill, the Misuku Hills, the hill areas north-west and west of the Nyika Plateau, the broad, deeply dissected scarp zones east and south of the Nyika Plateau, the hills of Central Mzimba, the Visanza-Dowa Hills, the Dedza Highlands, the hills of the Namwera and Blantyre-Limbe areas, and the Cholo Hills. Mwera Hill Station is situated in this unit.

(iii) *The Medium-altitude Plains.* These are gently undulating to almost level plains, lying at altitudes of 3,400–4,500 ft. in Northern and Central Provinces, and 2,000–3,500 ft. in Southern Province. They are the most extensive of the major

relief units, and contain the majority of agricultural land in Nyasaland. The principal subdivisions are the Fort Hill Plain; the Upper South Rukuru Basin; the Lilongwe Plain, which covers most of Lilongwe District and extends into Dowa, Kasungu, Fort Manning and Dedza Districts; and the Lake Chilwa Plain, or Shire Highlands, covering most of Zomba District and parts of Kasupe, Blantyre, and Mlanje Districts. Chitedze, Bvumbwe, Tuchila, Makoka, Mbawa, and Mimosa Stations are situated in this unit.

(iv) *The Rift-Valley Scarp Zone.* This consists of belts of deeply-dissected, steeply-sloping country bordering the Rift Valley. It is of little agricultural value due to the dominance of thin, stony soils. It comprises the scarp zones west of Lake Nyasa, and west of the Bwanje Valley, the Piri-longwe Hills between the Bwanje and Upper Shire Valleys, the scarps east of the Upper and Lower Shire Valleys, including the Cholo Scarp, the scarp zone east of the Kirk Range, the hills of the Middle Shire Valley, and the Port Herald Hills.

(v) *The Rift-Valley Floor.* This consists mainly of level plains of alluvial origin; undulating areas of low relief also occur. It includes three subdivisions. The lake shore plains of Lake Nyasa lie at 1,550–2,000 ft., and comprise the lake shore plains of Karonga, Nkata Bay, Kota Kota, and Salima; Chitala Station lies in this region. The Upper Shire Valley, between Fort Johnston and Matope, lies at 1,500–1,800 ft.; the Bwanje Valley occupies an intermediate position between this region and the lake shore plains. The Lower Shire Valley, between Chikwawa and Port Herald, lies at an altitude of 100–300 ft., and includes Makanga Station.

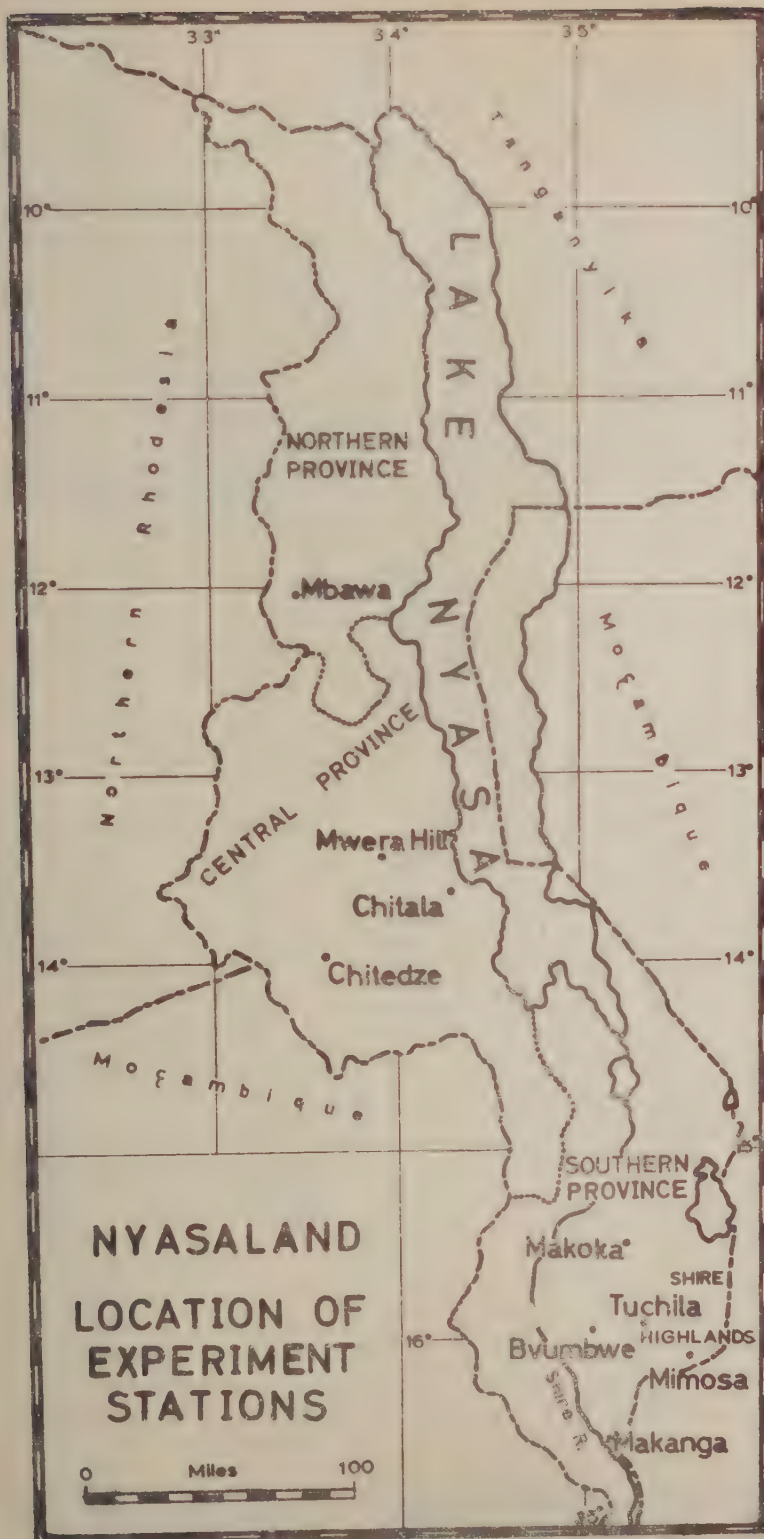
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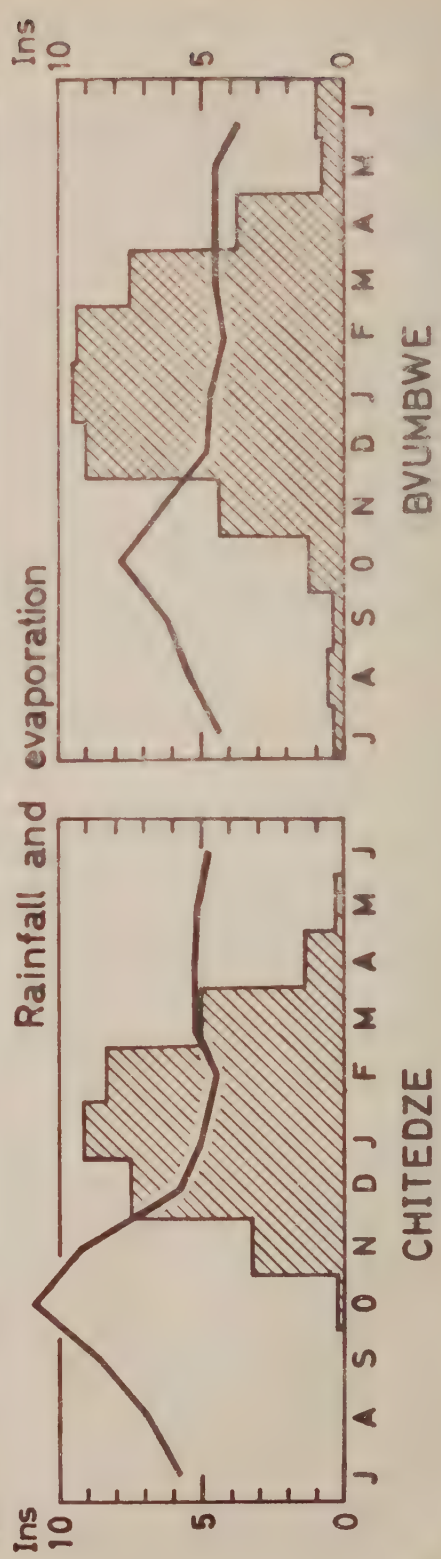
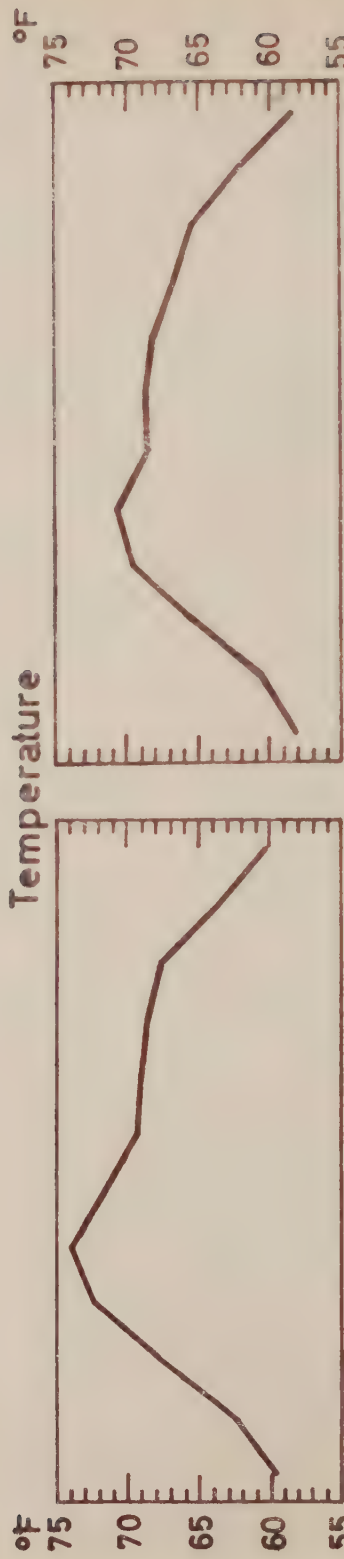
All parts of Nyasaland receive a rainfall adequate for agriculture; the lowest recorded mean annual total is 25.3 in. although it is possible that parts of west Mzimba District receive slightly less than this. A large proportion of the country receives 30–45 in. There are three high-rainfall areas with over 60 in.: Mlanje, Nkata Bay, and at the northern end of Lake Nyasa. The principal feature of this rainfall is its high degree of concentration in a single wet season; this could be considered the most important single factor in the Nyasaland environment, in view of its widespread effects on other factors. Over a large proportion of the country 80–90 per cent. of the rainfall occurs in the four months December–March, and there is almost complete drought from May to October. In the Lower Shire Valley and the southern part of the Shire Highlands the corresponding figure is 70–80 per cent., with occasional light falls in the dry season. The high-rainfall areas of Nkata Bay and Mlanje are characterized by the continuation of the rains into April, and by dry-season falls of 5–10 in. These two parameters are included in table II, and the monthly rainfall for experiment stations is given in table III.

On the medium-altitude plains, mean annual temperatures are 67°–70°, rising to 73° on the lower-lying part of the Shire Highlands. There is considerable variation with altitude, from 55° on the Nyika Plateau to 78° in the Lower Shire Valley. There is also a smaller variation with latitude. The mean annual temperature for any site in Nyasaland at which no temperature records are available, but of which the approximate altitude is known, can be found from the following formula:

$$T = 86.5 - \left\{ \frac{3A}{1,000} + \frac{L}{2} \right\}$$

where T=mean annual temperature in degrees fahrenheit, A=altitude in feet, and L=latitude in degrees. The standard deviation between temperatures computed from this formula and recorded temperatures is ± 1.0 .





CHITEDZE

BVUMBWE

Measurements of evaporation have been made at most stations for only 5-6 years. In table I these short term measurements of mean annual evaporation are tabulated according to site. There is an approximate relationship as follows:

$$E = 3T - 136$$

where E = mean annual evaporation in inches, as measured in a standard raised screened pan, and T = mean annual temperature in degrees Fahrenheit. The standard deviation between recorded evaporation and values computed from this formula has, however, the moderately high value of ± 12.5 . The fact that the values for the Lower Shire Valley are no higher, and possibly lower, than those of the lake shore is probably due to lower wind velocities in the former, more sheltered area. In almost all parts of the country evaporation considerably exceeds rainfall in the months of May to November inclusive, and rainfall is greater than evaporation from January to March.

In fig. 2, climatic data are shown graphically for two stations at typical sites on the medium altitude plains; Chilolze is representative of Northern and Central Provinces, and Bvumbwe of Southern Province conditions.

TABLE I

Evaporation

Mean annual values, classified according to site

(The figures refer to evaporation from a standard raised screened pan)

Site	No. of stations	Evaporation, in.	
		Mean	Range
Plains of medium altitude, Northern and Central Provinces	5	75	66-90
Shire Highlands	6	68*	62-76*
Lake Nyasa shore	8	92	83-101
Shire Valley	4	88	80-95

* Excluding Chileka, sited in an exceptionally exposed position on an airfield, and recording 107 in

TABLE II
Climatic data for Experiment Stations

Station	Altitude ft.	Temperature °F.				Mean annual precipitation in. %	Rainfall			Mean annual evaporation in.
		Mean annual	Mean July	Mean November	Annual range		Mean annual in.	Days no drizzle in.	Proportion falling in rainy months %	
Chitedze	3,770	68.2	60.1	74.4	14.3	68	35.1	0.5	85	77.7
Byumbwe	3,760	66.6	59.5	71.6	12.1	77	48.3	4.6	73	62.0
Tuchila	2,300	71.6	63.7	77.5	14.1	—	34.2	1.9	70	—
Makanga	250	77.5	68.7	83.4	15.1	69*	32.1	3.1	76	78.1†
Makoka	3,360	68.6*	61.1*	74.4*	13.3*	—	40.0*	2.0*	79*	—
Mwera Hill	4,960	64.7	57.9	70.2	12.3	77*	40.6	0.9	88	—
Chitola	1,980	73.8	66.2	80.6	14.4	65*	31.6	0.3	89	—
Mbawa	4,080	68.3*	61.0*	74.0*	13.0*	—	31.6	0.5	89	—
Mimosa	2,140	71.5	63.3	77.2	13.9	—	69.9	11.1	65	66.2

* Estimated.

† This value refers to a moderately sheltered site; records for two years at a more exposed site give values approximately 10 in. higher.

TABLE III
Monthly Rainfall at Experiment Stations

Station	Rainfall, in.												
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Year
Chitedze ..	0.0	0.0	0.1	0.1	3.2	7.5	9.1	8.3	5.0	1.4	0.3	0.1	35.1
Bvumbwe ..	0.5	0.4	0.3	1.3	4.5	9.0	9.5	9.4	7.5	3.7	0.8	1.0	48.3
Tuchila ..	0.1	0.2	0.0	0.4	4.9	6.6	6.3	6.3	4.6	3.5	0.7	0.5	34.2
Makanga ..	0.4	0.3	0.3	0.6	3.4	6.3	6.6	7.0	4.4	1.3	0.7	0.7	32.1
Mwera Hill ..	0.0	0.2	0.1	0.3	1.7	6.0	10.0	12.5	6.8	2.8	0.2	0.0	40.6
Chitala ..	0.0	0.0	0.1	0.1	1.6	5.8	9.5	9.0	6.5	1.4	0.1	0.0	34.1
Mbawa ..	0.0	0.0	0.2	0.1	1.5	8.4	7.9	7.1	4.8	1.4	0.2	0.1	31.6
Mimosa ..	1.2	1.7	1.1	2.8	7.8	10.4	12.2	11.7	11.0	5.5	2.1	2.2	69.9

Records at Makoka cover an insufficient period to provide reliable monthly mean values; the seasonal distribution of rainfall is similar to that at Bvumbwe.

VEGETATION

Nyasaland lies within the belt of *Brachystegia* woodland which occupies an area of approximately three million square miles in East Africa south of the Equator. This vegetational formation is characterized by the predominance of *Brachystegia*, *Jubbernardia*, and *Isoberlinia* species. It occupies most parts of the medium-altitude plains, and the hill areas at all altitudes. When undisturbed this formation becomes a woodland of trees of medium height. Over most parts of Nyasaland, however, it has been reduced by cutting and burning to the degenerate form of a savanna woodland, or open woodland, of short trees. Byumbwe, Tuchila, Makoka and Mbawa Stations occur amid areas with this vegetation.

The high-altitude plateaux, and certain of the higher hill areas, carry a vegetation of montane grassland. This is believed to be a fire-climax, having replaced a former cover of montane forest, and in the lower parts, *Brachystegia* woodland. Mwera Hill Station lies amid this vegetation. A limited area comprising the better soils of Lilongwe District, and including the site of Chitedze Station, has as its natural vegetation a broad-leaved deciduous woodland, with *Acacia campylacantha*, *Piliostigma thonningii*, and *Combretum* species common. The lake shore plains and the Shire Valley have a savanna and thicket vegetation, characterized by *Adansonia digitata* (baobab), *Acacia* species, *Hyphaene ventricosa* (palm) and *Sterculia* species; Chitala and Makanga Stations lie in this area.

Owing to the high population of Nyasaland the vegetation in many parts has been reduced to the status of cultivation savanna. This term refers to areas which are almost entirely under cultivation, with isolated trees remaining amid fields, along field-boundaries, and in small woodland or thicket patches. The whole of the broad-leaved deciduous woodland, and large parts of the lake shore and Shire Valley vegetation are in this condition.

SOILS

All freely drained areas in Nyasaland are occupied by latosols. These have in common the predominance of reddish colours, and a moderate to strong acidity, pH 4.0–6.0. They are moderately to strongly leached, with a subsoil base saturation varying from 80 to below 10 per cent. The clay minerals are predominantly of the kaolinitic type, and consequently even heavy-textured horizons tend to be friable and freely permeable.

The Rift Valley Floor is occupied mainly by calcimorphic soils, alluvial in origin and with imperfect site drainage. These are greyish brown in colour, weakly acid to neutral, and with a subsoil base saturation of close to 100 per cent.; their profiles frequently show depositional bedding. The clay minerals include substantial proportions of montmorillonite or illite, resulting in a plastic clay of low permeability.

The hill areas at all altitudes mainly carry lithosols, soils too thin and stony for cultivation; limited areas of deep red soils also occur within them, in which the typical characteristics of latosols occur in an accentuated form. Poorly-drained sites in all regions are occupied by hydromorphic soils, consisting usually of black or mottled heavy clays.

The most important factors in the genesis of Nyasaland soils originate from the seasonality of the rainfall (see above). During the rainy season all freely-drained soils are subject to strong leaching; soils with impeded drainage undergo waterlogging in this period. In the dry season the excess of evapo-transpiration over rainfall results in a drying out of the upper horizons of the soil, with a resultant tendency towards the deposition of substances held in solution or colloidal suspension. Comparative studies in soil drying under different cropping treatments have been carried out at

Chitedze and Mimosa Stations, and are reported in *Ann. Rep. Dept. Agric.* 1957, 58, Pt. II, pp. 85-87, 138-139, and *ibid.* 1959, 60, pp. 93-94, 139-142 and in this report pp. 182-3.

In subdividing the very wide group of latosols, the classification of the Inter-African Pedological Service has been employed in the soil descriptions given below. This classification has received a wide measure of acceptance in countries of Africa south of the Sahara, including both Northern and Southern Rhodesia. The three major subdivisions are ferruginous soils, ferrisols, and ferallitic soils.

Ferruginous soils are dark red, red, or dark reddish brown in colour, with a subsoil texture of clay or sandy clay. They have a strongly developed fine or medium blocky structure in the subsoil; the soil breaks up readily into well defined structural aggregates, or peds. These peds have coatings of clay particles, giving to their surfaces a slightly shiny appearance and often a slightly darker colour than that of the ped interiors; these coatings, formerly known as "clay skins", are termed *ped cutans* (*J. Soil Sci.*, II, 1960, pp. 280-292). Ferruginous soils are typically of moderate acidity, pH 5.0-5.5, and have moderate subsoil base saturation, 50-80 per cent. A substantial content of weatherable rock minerals, i.e. minerals other than quartz and muscovite, is present in the profile. This soil group is normally of moderate or relatively high fertility. In Nyasaland it occurs north west of Mazui; on the Dowa, Lilongwe, and Dedza portions of the Lilongwe Plain; on the freely drained parts of the Shire Highlands with a rainfall of below 50 in.; and in the Visanza-Dowa Hills, the Dedza Highlands, and the Kirk Range. Chitedze, Bvumbwe, Makoka, and Mwera Hill Stations include ferruginous soils.

Ferrisols are deep, red or dark red soil with a clay or sandy clay texture in all horizons. They typically have a weak blocky structure, which breaks down into weak fine crumb; *ped cutans* may or may not be present in the subsoil but are clearly developed in the deeper horizons. A marked feature of this group is the absence of any clear textural differentiation within the profile, the clay content remaining very similar over considerable depths. Ferrisols are strongly acid, pH 4.0-5.0, and as a result their plant nutrients tend to be very unavailable. Their subsoil base saturation is commonly 20-40 per cent. The clay minerals belong almost entirely to the kaolinitic group; as a result of this, the clays remain in a flocculated condition, and even horizons containing 50-65 per cent. of clay are freely permeable. This group occurs in areas with more than 60 in. mean annual rainfall, and is utilized for perennial crops. The Nyasaland tea-growing areas, including Mimosa Station, possess ferrisols; coffee and tung are grown partly on ferrisols and partly on ferruginous soils. The principal occurrences are between Nkata Bay and Mzuzu, and at Cholo and Mlanje.

Ferallitic soils are yellowish red, reddish brown, or less commonly red in colour; they normally have a sandy topsoil, and the lower horizons are frequently, but not invariably, moderately sandy. They are characterized by the absence of any clearly-defined structural aggregates in the subsoil; the structure is massive to single-grain, or at most very weakly-developed blocky. No *ped cutans* are visible. The group is moderately to strongly acid, pH 4.5-5.5, and the subsoil base saturation varies from 30 to 80 per cent. The content of weatherable rock minerals is very low or nil. These soils are normally of low fertility. They occupy large sections of the medium-altitude plains, particularly in Northern Province and Kasungu District; substantial areas also occur in Fort Manning District, Central Dedza District, and in parts of the Shire Highlands. The soils of Mbawa Station and of a large part of Tuchila Station are ferallitic.

The high-altitude plateaux carry a subdivision of this group termed *humic ferallitic soils*. These are yellowish red to red, weakly structured, strongly acid, and very strongly leached. They differ from other Nyasaland soils in possessing a high topsoil organic-matter content.

Fig. 3 shows a provisional map of zones of fertilizer response. Nitrogen is deficient in most Nyasaland latosols, associated with their low organic matter content; responses to nitrogenous fertilizers are obtained in all parts of the country except certain Rift Valley floor areas of calcimorphic soils. The ferallitic soils of Northern Province and Kasungu District give responses to phosphates, and recently a sulphur-deficiency has been identified in many of these. The Visanza-Dowa Hills and the Dedza Highlands, both areas of ferruginous soils, have the anomalous feature of revealing a phosphorus deficiency on analysis, but giving little response to phosphates. Potash is normally adequate in Nyasaland.

In the descriptions of soils on experiment stations which follow, the names of *soil series* are given where these have been identified. Full series definitions will be published in forthcoming memoirs on Northern Nyasaland (*in the press*), and Central Nyasaland (*in course of preparation*). With the exception of Makanga Station, no series are given for Southern Province stations, since systematic soil surveys have not been carried out over much of this Province. The colours given in profile descriptions below are field colours of moist soil. Reference should be made to the analytical data given in tables IV and V.

TABLE IV
Mechanical Analyses of Soils from Experiment Stations

<i>Station and soil series</i>	<i>Depth in.</i>	<i>Gravel %</i>	<i>Coarse sand %</i>	<i>Fine sand %</i>	<i>Silt %</i>	<i>Clay %</i>	<i>Texture</i>
Chitedze; Lilongwe series ..	0-5	0	29	23	12	36	Sandy clay
	5-12	0	22	24	14	40	Sandy clay
	12-28	0	22	20	12	46	Clay
	28-65	0	23	25	16	36	Sandy clay
Bvumbwe	0-6	—	32	29	12	27	Sandy clay loam
	6-20	—	21	24	9	46	Sandy clay
	20-43	—	11	19	12	58	Clay
	43-65	—	15	16	14	55	Clay
Tuchila	0-15	—	23	41	16	20	Sandy loam
	15-30	—	23	33	14	30	Sandy clay loam
	30-45	—	29	30	13	28	Sandy clay loam
	45-60	—	24	28	16	32	Sandy clay loam
Makanga; Tomali series ..	0-6	—	5	52	20	23	Fine sandy clay loam
	6-18	—	1	41	31	27	Clay loam
	18-36	—	0	39	37	24	Loam
	36-60	—	1	74	18	7	Fine sandy loam
	60-70	—	1	70	17	12	Fine sandy loam
Makoka	0-4	2	42	44	7	7	Loamy sand
	4-8	2	37	24	10	29	Coarse sandy clay loam
	8-30	5	32	18	10	40	Coarse sandy clay
	30-42	4	26	24	17	33	Sandy clay loam
	42-48	1	18	31	18	33	Fine sandy clay loam
Mwera Hill	0-8	1	36	20	13	31	Sandy clay loam
	8-22	1	27	19	15	39	Sandy clay
	22-36	3	17	10	24	49	Clay
	36-54	1	25	19	15	41	Clay
Chitala; Chitala series ..	0-4	1	46	28	8	18	Coarse sandy loam
	4-18	2	36	19	3	42	Coarse sandy clay
	18-30	2	34	15	4	47	Coarse sandy clay
	30-72	3	33	15	11	41	Coarse sandy clay
Mbawa; Loudon series ..	0-6	0	29	37	5	29	Sandy clay loam
	6-21	2	23	34	8	35	Sandy clay
	21-40	2	27	15	14	44	Clay
	40-60	32	—	—	—	—	Iron concretions
Mimosa	0-9	0	14	12	14	60	Clay
	15	0	15	11	11	63	Clay
	30	0	14	9	11	66	Clay
	60	0	13	8	21	58	Clay
	132	1	8	22	25	45	Clay

Particle-size classes are those of the International System, as follows: gravel, >2.0 mm.; coarse sand 0.2-2.0 mm.; fine sand 0.02-0.2 mm.; silt 0.002-0.02 mm.; clay, <0.002 mm. Gravel is expressed as a percentage of fine material (<2.0 mm.).

TABLE V
Chemical Analyses of Soils from Experiment Stations

Station and soil series	Depth in.	pH	Organic matter, % (=Org. C × 1.724)	Ca, %	N, %	ratio	Exchangeable cations				Cation capacity m.e. %	Base saturation %	Phosphates, p.p.m.	
							K	Ca	Mg	Na	Total		(NH ₄ F extract)	(HCL, NH ₄ F extract)
Chitedze; Lilongwe series	0-5	6.0	2.2	1.3	0.10	12.1	1.2	1.3	1.5	—	18.0	30	—	—
	5-12	5.7	1.2	0.7	0.07	9.4	0.5	6.3	1.4	—	8.2	73	† tr	—
	12-28	5.7	—	—	—	—	0.3	3.3	0.3	—	3.9	55	† tr	—
	28-65	6.0	—	—	—	—	0.2	2.0	0.3	—	2.5	58	† tr	—
Bvumbwe	0-6	5.7	4.5	2.8	0.21	11.6	0.38	6.6	1.6	0.37	8.3	60	100	318
	6-20	5.1	—	—	—	—	0.21	2.4	1.2	0.34	4.1	48	† 163	† 326
	20-43	5.3	—	—	—	—	0.15	2.2	0.8	0.34	3.5	38	—	—
	43-65	5.5	—	—	—	—	0.10	2.6	1.0	0.36	4.0	40	—	—
Tuchila	0-15	6.2	3.1	1.8	0.13	13.8	0.47	9.2	—	—	—	85	† 17	† 40
	15-30	6.3	—	—	—	—	—	—	—	—	—	83	—	—
Makanga; Tomali series*	0-6	6.1	4.5	2.7	0.19	13.9	2.2	14.4	5.4	0.12	22.1	100	158	695
	6-24	6.3	1.7	1.0	0.07	13.6	0.43	9.4	2.2	0.26	12.3	87	† 31	† 343
	24-40	6.6	—	—	—	—	0.33	8.8	2.0	0.17	11.3	81	—	—
	40-70	7.0	7.0	—	—	—	0.25	7.0	1.6	0.14	8.9	89	—	—
Makoka	0-4	6.0	0.7	0.4	0.04	11.8	0.21	2.8	0.6	0.06	3.7	68	† 40	† 106
	4-8	5.7	0.5	0.3	0.03	9.8	0.23	4.8	1.4	0.05	6.5	76	† 43	† 88
	8-30	5.7	—	—	—	—	0.23	5.4	2.3	0.05	8.0	80	—	—
	30-42	5.7	—	—	—	—	0.18	6.0	2.5	0.08	8.8	84	—	—
	42-48	5.7	—	—	—	—	0.14	5.8	2.4	0.08	8.4	88	—	—

* Total soluble salts 0.02-0.04 per cent. in all horizons of Tomali series, at all other stations, soluble salts absent or very low.

† Extraction for one minute—Chitedze.

‡ Extraction for fifteen minutes—Bvumbwe.

TABLE V
Chemical Analyses of Soils from Experiment Stations

Station and soil series	Depth in.	pH	Organic matter % (=Org. C × 1.724)	Carbon %	Nitrogen %	C/N ratio	Exchangeable cations m.e. %				Cation exchange capacity m.e. %	Base saturation %	Phosphates, p.p.m.	
							K	Ca	Mg	Na	Total		Available (NH ₄ F extract)	Reserves (HCL, NH ₄ F extract)
Mwera Hill; Mwera Hill series	0-24	5.2	1.3	0.7	0.12	0.3	0.55	7.4	3.2	—	11.2	90	2.25	—
	24-48	5.5	0.8	0.5	0.10	4.8	0.67	6.5	2.5	—	9.7	75	1.1	—
	48-72	5.0	—	—	—	—	1.13	5.9	1.6	—	8.6	70	1.1	—
Chitala; Chitala series	0-5	6.1	—	—	0.69	—	0.58	7.3	1.5	—	9.4	88	2.5	—
	5-20	6.7	—	—	0.63	—	0.51	9.5	2.3	—	12.3	89	1.1	—
	20-60	6.9	—	—	—	—	0.26	8.0	2.0	—	10.2	83	1.1	—
Mbawa; Loudon series	0-6	5.9	0.8	0.4	0.05	9.8	0.39	1.3	0.4	—	2.1	75	1.06	—
	6-21	5.5	0.2	0.1	0.02	5.4	0.36	1.7	0.2	—	2.3	70	1.4	—
	21-40	5.2	—	—	—	—	0.40	0.9	0.8	—	2.1	68	1.1	—
	40-60	6.0	—	—	—	—	0.42	1.0	0.7	—	2.2	73	1.1	—
Mimosa	0-6	4.4	2.8	1.6	0.14	11.4	0.23	2.6	0.0	0.1	2.9	34	1.66	2.17
	6-12	4.5	2.6	1.5	—	—	0.07	1.4	0.4	0.1	2.0	33	1.22	1.60
	12-18	4.6	—	—	—	—	0.06	3.1	0.3	0.1	3.3	36	—	—
	18-40	4.9	—	—	—	—	0.03	3.8	0.2	0.1	4.4	68	—	—
	40-75	4.9	—	—	—	—	0.04	3.0	0.3	0.1	3.4	59	—	—

† Extraction for one minute.
* Extraction for fifteen minutes.

Chitedze Agricultural Research Station

Location. Ten miles west of Lilongwe, Lilongwe District, Central Province; latitude 13° 59' south, longitude 33° 38' east, altitude 3,770 ft.

Experimental work. Maize, groundnuts, tobacco (dark fire-cured, sun-cured, Burley); plant breeding, variety trials, fertilizer trials, general agronomy. Other legumes, other root crops: general agronomy. Rotations. Grassland studies. Chemical weed control. Unit farm. (Chemical laboratory): soil analysis, plant analysis soil moisture studies.

Landforms. Chitedze is situated in the centre of an extensive plain, lying at 3,400-4,000 ft., which covers much of Central Province. This plain is characterized by level areas on the interfluvial crests, and very wide valleys with gently-sloping sides and broad, concave, marshy floors. The station includes interfluvies with slopes of 0°-1°, valley sides sloping at 1°-2°, and the heads of two shallow tributary valleys.

Climate. Both temperature and rainfall are moderate (see tables II and III). There is a high degree of concentration of rainfall in a single season, with almost complete drought for six months of the year.

Vegetation. In this area, *Combretum-Acacia-Piliostigma* woodland, a former cover of broad leaved deciduous woodland, has been entirely replaced by cultivation savanna. The commonest trees are *Combretum glazalense*, *C. guenzii*, *Acacia campylacantha*, *Piliostigma bionnigii*, *Erythrina tomentosa*, *Aframoria angolensis*, *Pterocarpus angolensis*, and *Strychnos spinosa*; the grasses are dominated by tall *Hyparrhenia* species.

Soils. A well-developed catena of five members occurs, as follows: on the interfluvies, the Lilongwe series, a dark red clay or sandy clay; on upper valley sides, the Kandiani series, a yellowish red sandy clay; on lower valley sides, the Mwanjema series, a dark brown sandy clay; at valley heads and valley floor margins, the Maonde series, a brown sandy loam or loamy sand; and in valley floors the Mbabzi series, a black clay. Arable experimental work is principally carried out on the Lilongwe and Kandiani series, and pasture research on the Mwanjema and Maonde series.

The *Lilongwe series* is a ferruginous latosol, moderately acid and moderately leached. It is heavy-textured but freely drained, and the profile is deep. The structure is strongly developed. A typical profile on the station is as follows (cf. tables IV and V);

- | | |
|-----------|--|
| 0-5 in. | 5YR 3/3 dark reddish brown, sandy clay; permeability rapid; clear boundary. |
| 5-12 in. | 5YR 3/4 dark reddish brown clay; moderate fine to medium blocky structure with weak ped cutans, moderately stiff when wet; merging boundary. |
| 12-28 in. | 2.5YR 3/4 dark reddish brown clay; permeability moderate, moderate medium blocky structure with moderate ped cutans, moderately stiff when wet; gradually merging boundary. |
| 28-65 in. | 2.5YR-10R 3/6 dark red sandy clay, permeability rapid, weak blocky structure; easily friable when moist, much softer than the above horizons despite similar texture; only slightly stiff when wet; no weathered rock present. |

The *Kandiani series* is also freely drained and the texture is similar to that of the Lilongwe series, but the colour is dark brown in the subsoil and yellowish red (the 5YR) in the deeper horizons; in contrast to the Lilongwe series, the subsoil

structure is weak or very weak blocky. In the *Mwanjema series* the texture is again similar, but the dark brown subsoil colour extends to a depth of at least 24 in.; in depth the colour is brown to reddish brown (between hues 5YR and 7.5YR), and is frequently mottled; the site drainage is imperfect. These two series are weakly ferallitic.

The *Maonde series* contains much coarse sand, the topsoil and subsoil varying from sandy loam to loamy sand; almost pure sand occurs at one valley head site on the station. The series has impeded site drainage, and the lower horizons are prominently mottled. It is strongly ferallitic. Massive laterite, consisting of hard, strongly-cemented iron concretions, frequently occurs in depth.

The *Mbabzi series* is a hydromorphic soil in which both site and profile drainage are poor. All horizons consist of black clay, with a strong, very coarse, blocky structure. In contrast to the other members of the catena, the clay minerals are dominantly of the montmorillonitic type, resulting in a clay that is of very slow permeability, and very stiff when wet.

Area represented. Climatically the station is representative of those parts of the plains of medium altitude which lie in Northern and Central Provinces and have a rainfall of 30-40 inches. Pedologically it is similar to the better-soil areas of Lilongwe District, the section of Dowa District lying west of the Great North Road, a large part of north-west Dedza District, and a small area in the extreme east of Fort Manning District.

Bvumbwe Tung and Agricultural Experiment Station

Location. Eight miles south of Limbe, Blantyre District, Southern Province; latitude 15° 55' south, longitude 35° 04' east, altitude 3,760 ft.

Experimental work. Coffee (*Coffea arabica*): variety trials, pathology, general agronomy, irrigation, economics of production. Tung (*Aleurites montana*): fertilizer trials, oil analysis. Fruit and vegetables, general agronomy. Grassland studies. Mixed farming, including dairying. Rotations. Chemical laboratory: soil analysis, plant analysis, oil-seed analysis, micro-nutrient studies.

Landforms. Bvumbwe is situated on the section of the medium-altitude plains known as the Shire Highlands. This is tilted to the east, away from the Rift Valley, and the station lies on its higher, western part. This part is dissected to moderate depths, with gentle and moderate slopes. The station includes a level interfluvial crest, valley sides sloping mainly at 2°, reaching 3°-4° in places, and gentle, shallow depressions formed by the heads of small tributary valleys.

Climate. The mean annual rainfall is 48.3 in., intermediate between that of the greater part of the Shire Highlands and of the tea-growing areas of Cholo and Mlanje. The rainy season continues into April in some years, and light falls occur during the dry season. Temperatures are moderate.

Vegetation. The station was formerly occupied by *Brachystegia-Julbernardia* woodland which may, however, have been of secondary origin. Due to the high population, a large part of the surrounding area carries cultivation savanna.

Soils. A well-developed catena is present on the station. The level interfluvial crest is occupied by a deep, red sandy clay or clay with ferruginous characteristics; the valley sides have yellowish red, more sandy profiles; and the base of the catena is formed of very sandy soils. Coffee and tung experimental work is carried out principally on the deep red soil type, the mixed farm is situated on the yellowish red type, and pasture studies are carried out on the yellowish red and the very sandy types.

The upper member of the catena is dark red or red from the sub-soil downwards, with a sandy clay or clay texture; it has a strongly developed subsoil structure, with ped cutans clearly visible. The depth of the profile commonly exceeds ten feet. It is moderately acid, pH 5.0-5.5, with a moderate subsoil base saturation, 40-70 per cent. Both the profile morphology and the analytical characteristics are typical of ferruginous soils. The nutrient status is moderate to high. A normal profile is as follows:

- 0-6 in. 5YR 3/3 dark reddish brown sandy clay loam; moderate medium blocky structure; clear boundary.
- 6-20 in. 2.5YR 3/6 dark red, sandy clay; permeability moderate, strong fine blocky structure, strong ped cutans; moderately stiff when wet; merging boundary.
- 20-43 in. 2.5YR 4/8 red, with ped cutans 4/6 red, sandy clay; permeability moderate, strong fine angular blocky structure, strong ped cutans; less stiff than above.
- 43-50 in. Weakly developed stone line, 35 per cent. weathered rock and quartzite, with soil as above; penetrable by roots (this horizon is frequently absent).
- 50-65 in. 2.5YR, 4/8 red, sandy clay loam, moderate medium blocky structure, many rock minerals, few small patches of very highly weathered rock; easily friable, much softer than above despite similar texture.

On the valley sides the sub-soil colour changes to yellowish red, and the structure becomes weak. Laterite horizons, either massive or formed of moderately to strongly cemented peat iron concretions, frequently occur within the profile. Mottling may occur in depth, due either to imperfect site or profile drainage. At valley-floor margins, and in valley-head depressions, the topsoil and subsoil consist of a dark grey coarse sand or loamy coarse sand; this overlies a grey, mottled clay.

Area represented. Climatically and pedologically, the higher, western parts of the Shire Highlands, with a rainfall of 40-55 in.

Tuchila Experiment Station

Location. 22 miles south-east of Limbe, Mlanje District, Southern Province; latitude 15° 55' south, longitude 35° 20' east, altitude 2,300 ft.

Experimental work. Maize, groundnuts, dark fire-cured tobacco: variety trials, general agronomy. Grassland studies. Rotations.

Landforms. Tuchila is situated on the lower, eastern part of the Shire Highlands, a section of the medium-altitude plains. This part has only shallow dissection, and very gentle to gentle slopes. The majority of the station lies on the valley side of the Tuchila River, sloping evenly at 1°; the western margin reaches to a level interfluvial crest.

Climate. The mean annual rainfall is 34.2 in.; the rainy season continues into April, but from May to October only very light falls occur. Temperatures are moderate to high.

Vegetation. The station lies in an area of *Brachystegia-Julbernardia* woodland, much of which has been reduced to the state of cultivation savanna.

Soils. The greater part of the station is occupied by a greyish brown, sandy, fully ferallitic soil. Massive laterite or strongly cemented iron concretions commonly occur at approximately 36 in. or deeper. The structure is massive in all horizons, and ped cutans are absent. The horizon overlying the laterite is mottled, due to imperfect profile drainage. The soil is weakly acid and of low fertility. A typical profile is as follows:

- 0-6 in. 10YR 2/2 very dark brown, sandy loam; massive; merging boundary.
- 6-20 in. 7.5YR 3/2 dark brown, sandy clay loam; permeability moderate to rapid, massive; merging boundary.
- 20-38 in. 10YR 4/1 dark grey, with faint common 7.5YR 3/2 dark brown mottle, slightly gravelly sandy clay loam; massive, ferric iron concretions; sharp, wavy boundary.
- 38-60 in. massive laterite, vesicular in parts, mainly ferric iron.

At the western margin of the station a weakly ferallitic soil occurs. The subsoil colour is yellowish red to reddish brown, in the 5YR hue or slightly less red. The subsoil texture is sandy clay, with a weak medium blocky structure and weak ped cutans. Laterite may occur in depth.

Area represented. Climatically, the lower and drier parts of the Shire Highlands, with a rainfall of 30-40 in. Pedologically, the poorer soil areas lying between the red soils of the wetter, western part of the Shire Highlands, and the calcimorphic and hydromorphic soils adjacent to Lake Chilwa.

Makanga Experiment Station

Location. Three miles north of Chiromo, Port Herald District, Southern Province; latitude 16° 32' south, longitude 35° 09' east, altitude 250 ft.

Experimental work. Cotton: plant breeding, general agronomy, Cotton Pest Research Scheme. Cocoa: sugar, general agronomy. Irrigation.

Landforms. Makanga is situated in the Lower Shire Valley, the broad floor of which lies mainly at 100-350 ft. altitude; it is nearly level, and consists of a deep layer of alluvium, deposited by the Shire River. The station has slopes of $\frac{1}{4}^\circ$ and less. It lies immediately adjacent to the Ruw River, a major left-bank tributary of the Shire, and is periodically subject to flooding by this river.

Climate. The Lower Shire Valley experiences very high temperatures. The mean maximum temperature is above 95° in October and November, falling to 81° in the coolest month; the highest recorded shade temperature is 113°. Rainfall is lowish and, due to the high temperatures and the frequent occurrence of storms of high intensity, rainfall efficiency is low.

Vegetation. A savanna with thicket patches has been partly replaced by cultivation savanna. The commonest trees are *Cordyla africana*, *Sterculia africana*, *S. appendiculata*, *Adansonia digitata* (baobab), *Hyphaene ventricosa* (palm), *Acacia spirocarpa* and *Combretum ghazalense*. Low-lying areas carry *Kigelia pinnata* and *Acacia xanthophloea*. The dominant grasses are *Urochloa pullulans* and *Setaria palustris*. Details are given in *Ann. Rep. Dept. Agric.* 1955/56, Part II, pp. 89-90 and *ibid.* 1959/60, pp. 196-198.

Soils. A large proportion of the station is occupied by alluvial calcimorphic soils belonging to the *Tomali series*. A full definition of this series is given in *Ann. Rep. Dept. Agric.* 1959/60, Part II, pp. 192-193. It is greyish brown in colour and is characterized by depositional bedding of horizons with different textures, including

beds of almost pure fine sand. The sequence of textures in the profile varies greatly from place to place, but in all cases fine sand is greatly predominant over coarse; the silt fraction is higher than in most other Nyasaland soils. The heavier horizons are weakly structured, and the sandy layers massive or single-grain. The reaction is slightly on the acid side of neutral, and base saturation is close to 100 per cent. This class of soil is one normally associated with semi-arid areas, having a rainfall considerably lower than that experienced at Makanga, a feature partly explicable by the low rainfall effectiveness. A typical profile is as follows:

- 0-6 in. 10YR 2/2 very dark brown fine sandy loam; permeability rapid; sharp boundary; this horizon consists largely of material deposited by the Ruvo floods of 1952 and 1956.
- 6-39 in. 10YR 3/1 very dark grey, with faint but common mottle 10YR 2/2 very dark brown, fine sandy clay loam with much silt; permeability moderate, weak medium blocky structure with moderate cutans; micaceous; sharp boundary.
- 39-46 in. 5YR 4/4 reddish brown loamy fine sand; single-grain structure.
- 46-51 in. 7.5YR 3/2 dark brown, with clear mottle 7.5YR 4/4 brown on sandier parts, fine sandy loam, massive.
- 51-58 in. 10YR 3/1 very dark grey, with common clear mottle 7.5YR 3/2 dark brown, fine sandy clay loam; massive.
- 58-65 in. 7.5YR 4/4 brown fine sand; single-grain structure.
- 65-72 in. As 51-58 in.

Irregular depositional bedding continues to between 8 and 14 ft., below which a thick layer of heavy clay occurs.

Area represented. Climatically, the Lower Shire Valley, from north of Chikwawa to Port Herald. Pedologically, the alluvial floor of this valley, with the exception of the area of "*makande*" soils near Ngabu.

Makoka Tobacco Demonstration Farm

Location. 13 miles south-west of Zomba, Zomba District, Southern Province; latitude 15° 33' south, longitude 35° 11' east, altitude 3,360 ft.

Experimental work. Flue-cured tobacco: demonstration of cultivation and curing methods, general agronomy.

Landforms. Makoka is situated in the higher, western part of the Shire Highlands, a section of the medium-altitude plains. This part is dissected to a moderate depth, with gentle and moderate slopes predominant. The majority of the station consists of valley sides sloping at 1°-3°; there are relatively narrow areas along interfluvial crests with 0°-1° slopes; whilst the streams are slightly incised, with narrow inner valleys sloping at 5°-7°.

Climate. The station has only been in operation for two years, and no long-term climatic records are available. Mean annual rainfall is probably approximately 40 in., with very light dry-season falls. Temperatures are moderate.

Vegetation. Much of the area is at present covered by *Brachystegia* woodland, but except on the stony hillsides this may be a secondary formation. *Ptilostigma thonningii* and *Acacia campylacantha* are common on the station, with tall *Hyparrhenia* species grasses. Poorly drained areas are occupied by grassland in which *Setaria* is usually dominant.

Soils. The majority of the station, both on the valley sides and interfluvial crests, is occupied by a dark red ferruginous latosol. There is characteristically a contrast between a sandy topsoil, sandy loam or in places loamy sand, and a considerably heavier textured subsoil, usually of sandy clay. Coarse sand is prominent in the sand fraction, and fine quartz gravel occurs. The subsoil is strongly structured, with clearly visible ped cutans, and contains many weatherable rock minerals. The profile is of moderate depth, with weathered rock at 36-48 in., and in places is shallow. It is moderately acid, with highish subsoil base saturation and a high nutrient status. Small quantities of montmorillonite are present in the clay minerals, although kaolinite is dominant. A typical profile is as follows:

- 0-4 in. 7.5YR 3/2 dark brown, loamy sand including much coarse sand; rapid permeability; clear boundary.
- 4-8 in. 5YR 3/4 dark reddish brown, coarse sandy clay loam; merging boundary.
- 8-30 in. 2.5YR 3/6 dark red, coarse sandy clay, with fine quartz gravel common; permeability moderate, strong fine blocky structure, strong ped cutans, weatherable rock minerals common; merging boundary.
- 30-42 in. 2.5YR 3/6 dark red sandy clay loam, less clay than above; some deposition of ferrous iron, including a few black concretions; merging, irregular boundary.
- 42-60 in. Highly weathered rock.

In the shallower profiles belonging to this soil type, a characteristic feature is the presence of iron concretions immediately above, and merging with, the upper boundary of weathered rock.

On the lower parts of the valley sides the colour becomes less red, and a laterite horizon may occur. Valley-floor margins and valley heads are occupied by a poorly-drained soil, in which 6-15 in. of loamy coarse sand overlies a grey, prominently mottled, clay.

Area represented. Climatically and pedologically the dissected western part of the Shire Highlands, extending from Blantyre to Zomba, with a rainfall of 35-50 in.

Mwera Hill Experiment Station

Location. 14 miles north of Dowa, Kota Kota District, Central Province; latitude 13° 27' south, longitude 33° 56' east, altitude 4,960 ft.

Experimental Work. Deciduous fruit and vegetables, coffee (*Coffea arabica*); general agronomy.

Landforms. Mwera Hill is situated amid a hilly area of high relief but moderate slopes. Slopes of 5°-15° are the most extensive, with gentler areas on the broadly convex interfluvial crests, and some steeper slopes. Valleys are up to 500 ft. in depth, and valley floors are relatively narrow.

Climate. The mean annual rainfall is 40.6 in., with a marked drought for six months of the year. Temperatures are lower than on the medium-altitude plains; it is probable that evaporation is also lower, approximately 60-65 in., although no records are available.

Vegetation. The region is occupied by montane grassland, with numerous scattered short trees of *Cussonia kirkii*; *Erythrina tomentosa* occurs as trees of medium height, mainly in valleys. This vegetation is probably a fire-climax, having replaced a former woodland cover.

Soils. The station contains strongly ferruginous latosols of a distinctive type, that occurs also in the other high altitude hill areas of the Dedza Highlands and the Kirk Range. This type is characterized by a subsoil with a reddish brown to dusky red colour (2.5YR 4/2, 4/4, 3/2 or 3/4), a heavy texture, **usually clay, and a strong structure.** In the *Mwera Hill series* the subsoil has the unusual colour of weak red (2.5YR 4/2), changing to reddish brown or red in depth. There is a strong or moderate blocky structure, and on parts of the station ped cutans are exceptionally strongly developed. Although kaolinitic clay minerals are dominant, substantial amounts of montmorillonite are also present. The profile is of moderate depth and is moderately acid. A typical profile description of the Mwera Hill series is as follows:

- 0-6 in. 2.5YR 3/2 dark reddish brown, sandy clay loam; rapid permeability; clear boundary.
- 6-26 in. 2.5YR 4/3 weak red, clay; moderate permeability; strong fine angular blocky structure with strong ped cutans, clearly visible as shiny surfaces; very sticky when wet; weatherable rock minerals common; merging boundary.
- 26-40 in. 2.5YR 4/4 reddish brown clay, with few quartz stones; structure as above; merging boundary.
- 40-72 in. 2.5YR 4/6 red, gravelly sandy clay; weak fine blocky structure, abundant rock minerals, patches of highly-weathered rock.
- 72-80 in. highly weathered rock.

Area represented. Climatically and pedologically, the station is closely representative of an area lying near to 5,000 ft. altitude and extending from north of Vianza to north of Dowa; the main part of the Dowa Hills, however, lie at a lower altitude, and have a different soil type and vegetation. Environmental conditions at Mwera Hill also have a moderate degree of similarity to those in the Dedza Highlands (east of Dedza), and in the Kirk Range.

Chitala Experiment Station

Location. 16 miles north-west of Salima, Dowa District, Central Province; latitude 13° 40' south, longitude 34° 17' east, altitude 1,980 ft.

Experimental Work. Cotton, maize, groundnuts: general agronomy. Rotations. Grassland Studies.

Landforms. Chitala is situated amid an area of country lying at the foot of the Rift Valley scarp, but a few hundred feet above the lake shore plain. The majority of this area is gently to moderately dissected, but the station lies on an extremely level surface remnant, with slopes of 0°- $\frac{1}{2}$ °.

Climate. Temperatures are high, but are 1°-2° below those characteristic of the lake shore plain. Mean annual rainfall is 34.1 in., with a very high degree of concentration in a single season, from December to March; the months of May to October are practically rainless.

Vegetation. In this region the most frequent trees are *Acacia campylacantha*, *Pterocarpus angolensis*, *Sterculia africana*, *Adansonia digitata* (baobab) and *Combretum ghalazense*. Along the station boundary *Acacia campylacantha* is dominant. There are substantial differences from the vegetation of the alluvial areas of the lake shore plain, including the absence of *Hyphaene ventricosa* (palm) and the presence of *Pterocarpus angolensis*.

Soils. A dark reddish brown, heavy-textured, ferruginous soil is present, the *Chitala* series. The combination of a level site and a texture which remains clay or sandy clay from the subsoil to a depth of more than 60 in. gives this series a strong tendency towards drainage impedance. As a result of this in very shallow depressions the series gives place to a mottled clay soil. The change between these two soils occurs with a difference of relief of as low as 2-4 ft. (2-12 in.) and of approximately equal extent on the station.

In the *Chitala* series the topsoil texture varies considerably from place to place, between sandy loam and sandy clay. The subsoil is a moderately structured, dark reddish brown sandy clay or clay, with weak or moderate ped cutans; in depth the structure becomes moderate or strong angular blocky. A typical profile is as follows:

- 0-4 in. 5YR 2/2 very dark reddish brown, coarse sandy loam; rapid permeability; clear boundary.
- 4-18 in. 5YR 3/4 dark reddish brown, coarse sandy clay; moderate permeability, weak to moderate medium blocky structure with weak ped cutans; merging boundary.
- 18-72 in. 2.5YR 3/6 dark red, coarse sandy clay to clay; moderate to slow permeability, strong medium angular blocky structure with moderate or strong ped cutans, moderately stiff and very sticky when wet, many weatherable rock minerals, few ferrous iron concretions, few patches of highly weathered rock.

In the mottled clay soil, permeability is slow and drainage is impeded. The texture is clay from the subsoil downwards, with a coarse angular blocky structure. A mottle commences in the subsoil, and becomes clear or prominent below 18 in.; it is formed of varied shades of reddish brown, yellowish red, strong brown and grey.

Area represented. Climatically, *Chitala* is representative of the drier parts of the lake shore plain, although it is slightly cooler. Pedologically it is an unsatisfactorily sited station. It contains ferruginous latosols, derived from Basement Complex gneisses, whereas the majority of the cotton growing areas of the lake shore plain, the Bwanje Valley, and the Upper Shire Valley possess calcimorphic soils formed on alluvium; the profile morphology, analytical properties and nutrient status of these two soil groups are strongly dissimilar. The station is also not representative of the low-altitude red soil region within which it lies, due to the level site and the tendency towards drainage impedance within the soil.

Mbawa Experiment Station

Location. 16 miles south-west of Mzimba, Mzimba District, Northern Province; latitude 12° 05' south, longitude 33° 29' east, altitude 4,080 ft.

Experimental work. Maize, groundnuts: fertilizer trials, general agronomy. Turkish tobacco: trials and seed production.

Landforms. Mbawa is situated in the upper section of the South Rukuru Valley, a part of the medium-altitude plains. This section of the valley consists of a plain with very gentle and gentle slopes, 20 miles in width and extending 70 miles in a north-south direction, with the South Rukuru flowing northwards in an asymmetric position near its western margin. The station is situated between the South Rukuru and its tributary the Chitara; it includes level crest areas, valley sides sloping at 1°-1½°, and the concave valley floor of the Mbawa Dambo.

Climate. The mean annual rainfall is 31.6 in., with a high degree of concentration in one season; 89 per cent. of the total falls in December-March, and there is an almost complete drought from May to October, continuing in most years through November. Temperatures are moderate.

Vegetation. The area is covered by *Brachystegia* woodland in which *Julbernardia paniculata* is very frequent. Other common tree species are *Brachystegia longifolia* and *B. boehmii*, *Julbernardia globiflora*, *Diplorrhynchus condylocarpon*, *Dichrostachys glomerata*, *Ochna schweinfurthiana*, and *Xeromphis obovata*.

Soils. The principal soil series on the station and in the surrounding area is the *Loudon* series, a weakly ferallitic latosol. There is a clearly developed illuvial (textural B) horizon of sandy clay or heavy sandy clay loam, which has a weak blocky structure. The subsoil colour is yellowish red or dark reddish brown, often becoming red or dark red in depth. It is moderately acid, pH 5.0–5.5, with a moderate subsoil base saturation, approximately 70 per cent.; the nutrient status is low to moderate, with nitrogen invariably low. A typical profile of the *Loudon* series is as follows:

- 0–6 in. 5YR 4/4 reddish brown, coarse sandy loam; rapid permeability; clear boundary.
- 6–21 in. 2.5YR 3/4 dark reddish brown, coarse sandy clay; permeability moderate, weak medium blocky structure, very weak ped cutans, friable; merging boundary.
- 21–60 in. 2.5YR 3/6 dark red, sandy clay loam; permeability rapid, friable, soft, very weak blocky structure breaking into very weak fine crumb; no weathered rock, few rock minerals.

Slight variations of this series occur on Mbawa station. On the interfluvial crest the profile is redder, with a red subsoil and very red lower horizons, approaching the 10R hue. On valley-sides the subsoil is yellowish red (5YR 5/8). In both these sites, horizons with many pea-iron concretions commonly occur in depth.

The valley-floor margins and the Mbawa Dambo have a coarse sandy soil with impeded site drainage. The floor of the South Rukuru valley is occupied by a hydromorphic clay soil.

Area represented. Both climatically and pedologically, the station is directly representative of the southern part of the Upper South Rukuru Valley. Its environmental conditions have a moderate degree of similarity with the northern part of this valley where, however, the rainfall is slightly lower and less reliable, and the soils are more strongly ferallitic and substantially poorer for agriculture.

Mimosa Tea Research Station (*Tea Association of Nyasaland and Rhodesia, Ltd.*)

Location. Ten miles east of Mlanje, Mlanje District, Southern Province; latitude 16° 05' south, longitude 35° 36' east, altitude 2,140 ft.

Experimental work. Tea: plant breeding, general agronomy, soil-moisture studies.

Landforms. Mimosa is situated in a dissected part of the medium-altitude plains, lying close to the scarp-foot on the south side of Mlanje massif. The country is dissected to a moderate depth, with valleys typically 100 ft. deep. Slopes of 5°–15° are the most common, and few level areas remain.

Climate. The climate is quite distinct from that of all other experiment stations, with a higher rainfall which is less strongly concentrated in a single season. The mean annual rainfall is 69.9 in., of which only 65 per cent. falls in the four wettest months; the rainy season normally commences in November and continues into April, and there is a substantial dry-season rainfall. Nevertheless, evaporation exceeds rainfall for six months of the year, and substantial depletion of soil moisture occurs during this season (*Ann. Rep. Dept. Agric.*, 1958/59, Pt. II, pp. 93–94; *ibid.* 1959/60, pp. 93–94).

Vegetation. The area was formerly occupied by moist evergreen forest and *Brachystegia* woodland, but is now largely under cultivation.

Soils. The station lies on a deep, red, clay to sandy clay, having the typical properties of a ferrisol. The profile is a uniform dark red from the subsoil downwards, and has a marked lack of textural differentiation, remaining clay or sandy clay from the subsoil to a depth of 8–10 ft. or more. The subsoil has a moderate blocky structure, breaking down into weak fine crumb; ped cutans are faint in the subsoil but become well-developed in depth. The consistency is friable and soft. These morphological characteristics result from the complete predominance of kaolinitic clay minerals, montmorillonite being absent. The profile is strongly acid, pH 4.5–5.0, and the subsoil base saturation is lowish. A typical profile is as follows:

- | | |
|-------------|--|
| 0–9 in. | 10R 3/4 dusky red, sandy clay (this colour refers to the soil under cultivation; under natural conditions it is probable that the colour would be dark reddish brown, with a moderate organic matter content); merging boundary. |
| 9–18 in. | 10R 3/6 dark red, clay; rapid permeability, moderate fine-medium blocky structure breaking into weak fine crumb, weak to moderate ped cutans, friable, soft; merging, imperceptible boundary. |
| 18–84 in. | 10R 3/6 dark red, clay; rapid permeability, moderate to strong blocky structure, moderate to strong ped cutans, consistency as above, few weatherable rock minerals. |
| 84–100 in. | 10R 3/6 dark red clay, weak blocky structure. |
| 100–132 in. | 10R 3/6 dark red, sandy clay; weak blocky structure, abundant rock minerals, few patches of highly weathered rock. |

Area represented. The deep red soil areas of Mlanje and Cholo, with a rainfall exceeding 55 in.

MAIZE AGRICULTURE

Fertilizer Trials

1. FERTILIZER TRIALS AT EXPERIMENT STATIONS

Routine fertilizer trials were conducted at Tuchila, and Chitala, and at Chitedze (A.R.S.) where plots were split between maize and tobacco to see what correlation, if any, there was between maize and tobacco yields. The experiments were factorial (3 x 3 and 4 replications at Tuchila, 3 x 2 and 6 replications at Chitala and 3 x 3 and 3 replications at Chitedze) testing nitrogen and phosphate, with blanket applications of potash applied to half the blocks at the first two stations.

TABLE I
Results of Routine Fertilizer Trials at Stations

Variety: see below

Yields: lb./acre grain

Treatment	Yield/acre			Cob No./acre			lb./cob		
	A.R.S.	Chitala	Tuchila	A.R.S.	Chitala	Tuchila	A.R.S.	Chitala	Tuchila
N ₀ -Nil ..	3,960	1,860	2,030	11,610	11,480	8,010	.558	.219	.343
N ₁ -100 S/A. ..	4,320	2,480**	3,430***	11,480	12,650	10,060	.616	.265	.461
N ₂ -200 S/A. ..	4,750**	2,710***	3,630***	11,960	12,640	10,510	.649	.289	.467
P ₀ -Nil ..	3,730	2,380	2,990	11,010	12,460	9,370	.554	.258	.431
P ₁ -200 Supers ..	4,650***	2,320	3,020	12,070	12,060	9,600	.630	.260	.425
P ₂ -400 Supers ..	4,660***	—	3,090	11,970	—	9,620	.636	—	.434
K ₀ -Nil ..	—	2,460	3,090	—	11,900	9,600	—	.279	.435
K ₁ -50 KCl ..	—	2,240	2,970	—	12,600	9,460	—	.240	.424
L.S.D. 5% N. ..	400	370	750	Soil type ..	..	S.C.L.	S.L.	S.C.L.	
L.S.D. 5% P. ..	460	310	760	pH. ..	..	5.8	6.2	5.0	
Mean ..	4,350	2,350	3,030	Total N. % ..	..	.172	.081	.215	
Coef. Varn. ..	10.5%	19.1%	29.5%	Available P p.p.m.	..	4	15	26	
Variety ..	Mthenga	Mlonda	Namle-nga	Exchangeable K. me. % ..	..	.32	.66	.46	

These figures show that even where sound ley rotations are followed and the soil is apparently fairly rich, good responses may still be obtained from small dressings of nitrogen. On red sandy clay loam at Chitedze 4 years harvesting of Rhodes grass ley for silage has again depleted soil phosphate supplies and a 200 lb./acre dressing of single superphosphate has given an excellent return. Fertilizers, where effective, reduce the number of barren plants and increase the size of individual cobs.

At Chitedze there was a significant correlation between maize yields and cob no., tobacco yield ($r = .867^{**}$, $n = 8$) and grade index ($r = .856^{**}$, $n = 8$) when the nine treatment combinations were compared. When considering nitrogen alone there was significant correlation between maize yield and tobacco yield ($r = .997^{**}$, $n = 2$) but not grade index ($r = .810$, $n = 2$). When considering phosphate alone there was significant correlation between maize yields and tobacco yield ($r = .962^{*}$, $n = 2$) and grade index ($r = .995^{**}$, $n = 2$). Actual yield figures are given below, and confirm previous findings that one can get a good idea as to whether tobacco will respond to

N and P, by examining records of maize trials, but that the correlation is not good enough to deduce the size of the responses to be expected. The effect of super-phosphate on tobacco quality as reflected by the grade index is stressed in the tobacco section.

TABLE II
Correlation between Maize Yields and Tobacco Yields and Grade Index

	Tobacco yield/acre	Maize yield/acre	Tobacco grade index
N ₀ —Nil	800	3,960	46.1
N ₁ —100 lb./acre S/A.	885	4,320	50.0
N ₂ —200 lb./acre S/A.	1,005	4,750	49.8
Correlation Coeff. r	.997** (n=2)	—	.810 (n=2)
P ₀ —Nil	840	3,730	45.8
P ₁ —200 lb./acre Supers	910	4,650	50.3
P ₂ —400 lb./acre Supers	940	4,660	49.0
Correlation Coeff. r	.962* (n=2)	—	.995** (n=2)

2. RESIDUAL FERTILIZER TRIALS

(a) Maize after Tobacco 3×3 NP Trials, Chitedze

On red brown sandy clay loams of the Lilongwe and Kandiani series which had shown small responses to both N and P on tobacco in 1959/60, the following maize crop showed no statistically significant residual effects. Mean yields were high, 23 bags and 27 bags of Mthenga maize respectively. Applications to the tobacco crop had been 100 and 200 lb./acre S/A and 200 and 400 lb./acre Single Supers.

(b) Maize after Tobacco 3×3×3 NPK trial, Chitedze

On dark brown sandy clay loam of Kandiani series which had shown marked responses to certain levels of N and P in 1959/60 tobacco crop, there was a significant residual response to phosphate only in the following maize crop.

TABLE III
Direct and residual effects of N, P and K on tobacco followed by maize

Varieties: Mthenga and Western

Yields: lb./acre grain and cured leaf

Treatment applied 1959/60	Tobacco 1959/60 (direct)	Maize 1960/61 (residual)
	yield/acre	yield/acre
N ₀ —Nil	665	5,210
N ₁ —150 lb./acre S/A.	865***	5,040
N ₂ —300 lb./acre S/A.	885***	5,380
P ₀ —Nil	585	4,850
P ₁ —250 lb./acre Supers	865***	5,280*
P ₂ —500 lb./acre Supers	955***	5,500**
K ₀ —Nil	755	5,160
K ₁ —60 lb./acre KCl	815	5,080
K ₂ —120 lb./acre KCl	840	5,400
Mean	800	5,210
L.S.D. 5%	90	310
Coef. Varn.	11.1%	5.2%

(c) *Maize after Tobacco 25/10/0 trial, Chitedze*

On dark brown sandy clay loam of the Kandiani series which had shown marked responses to both N and P in the 1959/60 tobacco crop, there were no statistically significant residual responses in the following maize crop. Some of the increases were large enough for attention but will require the confirmation of further trials.

TABLE IV
Direct and residual effects of 25/10,0 mixture and S/A and Supers on tobacco and maize

Varieties: *Mthenga and Western*

Yields: lb./acre grain and cured leaf

Treatment applied 1959/60						Tobacco 1959/60 (direct)		Maize 1960/61 (residual)
N. lb./acre	P ₂ O ₅ Fertiliser					Yield/acre	Grade Index	Yield/acre
0	0	Nil	..	..	..	630	16.4	3,770
25	10	25/10/0	..	..	..	760*	14.2	4,130
24	0	S/A	..	..	..	740*	15.3	4,670
24	10	S/A+Sup.	..	..	..	895***	17.6	4,500
50	20	25/10,0	..	..	..	825**	15.3	4,630
48	0	S/A	..	..	..	815**	15.0	5,080
48	20	S/A+Sup.	..	..	..	1,025***	15.3	4,430
Mean	..	..	..	..	..	815	15.6	4,460
L.S.D. 5%	..	..	..	..	..	110	3.3	1,030
Coef. Varn.	..	..	..	..	..	10.2%	15.8%	13.0%

(d) *Maize after Maize 3 × 2 NP trial, Chitedze*

On dark brown sandy clay loam of the Kandiani series there were marked residual responses to both nitrogen and phosphate though in the first year after ploughed up Rhodes grass responses were smaller and not statistically significant. The Rhodes grass had been ploughed in February, 1959, and a catch crop of cowpeas grown. Responses to sulphate of ammonia alone were small unless superphosphates were also applied. The phosphate gave bigger residual than direct responses, and residual NP interaction was statistically significant.

TABLE V
Direct and residual effects of N and P on maize grown in rotation with Rhodes grass
Variety: *Mthenga* Yields: lb./acre grain

Treatment applied 1959/60	Direct effect 1959/60					Residual effect 1960/61				
	Yield/acre				Cobs/ acre lb./ cob	Yield/acre				Cobs/ acre lb./ cob
	P ₀ —Nil	P ₁ —200 Sup.	Mean			P ₀ —Nil	P ₁ —200 Sup.	Mean		
N ₀ —Nil	4,370	4,570	4,470	11,040	.404	3,950	4,320	4,130	11,860	.534
N ₁ —200 lb. S/A.	4,230	4,210	4,220	10,280	.410	4,030	6,020	5,020**	12,520	.615
N ₂ —400 lb. S/A.	3,410	5,040	4,220	9,740	.433	4,520	4,960	4,740*	12,860	.565
Means	4,000	4,600	4,300			4,160	5,100***	4,630		
Cobs/acre	9,210	11,490	L.S.D. 5% N=870 P=710			11,780	13,050	L.S.D. 5% N=500 P=410		
lb./cob	.434	.400	Coef. Varn. 19.1%			.542	.599	Coef. Varn. 10.2%		

(e) *Maize after Groundnuts after Maize Phosphate Trial, Mbawa*

On phosphate deficient red sandy loam of the Loudon series maize still shows up small increases as a result of phosphate application in the 1958/59 season. Yields were however very low and raw rock phosphate still does not show up as well as other forms of phosphate.

TABLE VI
Direct and residual effects of phosphate on maize and groundnuts
Variety: *Local* Yields: lb./acre grain and kernels

Treatments applied 1958/59	Direct effect 58/59 maize†	1st year resid. G-nuts	2nd year resid. maize
Nil	740	530	1,340
200 lb./acre raw rock P.	570	550	1,520
400 lb./acre raw rock P.	740	610*	1,850
200 lb./acre Single Supers.	1,930***	780***	2,050
85 lb./acre Triple Supers.	1,890***	740**	1,850
200 lb./acre 25/10/0	1,070**	620	1,790
Mean	1,160	640	1,730
L.S.D. 5%	350	80	460
Coef. Varn.	20.9%	7.8%	17.5%

† N.B. All treatments except the last had a 200 lb./acre top dressing of S/A.

3. DISTRICT TRIALS

(a) *2×2×2 NPD trials at Kochira and Namizana*

Two exploratory NPD trials were conducted on rather worn-out acid soils at two sites in Fort Manning District, which have in the past given poor yields and disappointing responses from single fertilizer applications. Good yields were obtained at one site. At the other a poor, weedy stand gave miserably low yields with high errors once again and no conclusions can be drawn from this experiment. The evidence from Namizana points to the need for balanced fertilizers and farmyard manure.

TABLE VII
Responses to N, P and D on worn-out acid soils in Fort Manning
Variety: *Mthenga* Yields: lb./acre grain

Treatment	Namizana		
	Yield	Cobs/acre†	lb./cob
0	2,880	12,990	.317
N. 200 lb. S/A.	2,710	11,620	.333
P. 200 lb. Supers.	4,120***	12,990	.453
NP.	5,760***	13,630	.604
D. 5 tons F.Y.M.	4,350***	13,310	.467
ND.	4,800***	13,150	.521
PD.	5,590***	13,310	.600
NPD.	6,490***	13,630	.680
L.S.D. 5%	310	S.C.L.	pH=5.4
Mean	4,590	N.=.109	P.=9 p.p.m.
Coef. Varn.	3.7%	K.=.23	B.E.C.=9.9

† N.B. Plant population varied between 14,000 and 14 200 at Namizana.

(b) District NPD observation plots on Instructors' and Farmers' Gardens

A number of districts put out single replicate fertilizer plots on Instructors' and Master Farmers' gardens with up to five fertilizer treatments shown below.

TABLE VIII
Responses to fertilizers NP and D on district plots

Variety: Local unless otherwise stated

Yields: lb./acre grain

District and Area	No. of	Nil	N, 200 lb. S/A	P, 200 lb. Supers	N.P. S/A + Supers	D, 5 tons F.Y.M.	Notes
Chitedze, Lilongwe ..	6	3,730	4,970	4,030	5,320	4,390	Mthenga
Fort Manning, Kochira	3	630	1,050	—	1,480	430	Mthenga
Fort Manning, District	3	2,950	3,450	—	3,930	2,170	Mthenga
Dowa, Lake shore ..	1	3,540	4,790	3,740	3,220	2,170	
Dowa, Plateau ..	3	3,360	4,360	4,040	4,730	3,810	
Kota Kota, Lake shore	6	1,760	4,330	2,060	4,590	—	Mthenga
Kota Kota, Visanza ..	13	2,470	3,060	2,120	2,830	—	
Kota Kota, Mwera Hill	7	3,150	3,160	—	3,320	2,880	Mthenga
Dedza, Kachere ..	2	1,100	1,490	—	1,690	1,390	
Dedza, Highlands ..	3	460	780	540	890	590	
Ncheu ..	5	1,380	2,850	1,900	3,100	2,520	
Blantyre, Soche ..	1	2,800	3,400	—	4,370	3,240	
Blantyre, Lirangwe ..	3	1,940	2,690	2,730	—	—	N figures low probably termites
Mlanje S. ..	4	2,580	3,910	—	4,050	—	
Mlanje N. ..	5	1,990	4,250	—	4,170	—	

Apart from a general idea as to the levels of yield obtainable which may be a bit high, as the maize was not allowed to dry properly before being shelled, this shows an almost universal large response to nitrogen, which is only occasionally enhanced by the addition of phosphate. Phosphate alone appears to have given increases in certain areas, and it is of interest to note that there are indications that the red soils of the surrounds of Blantyre appear to respond, a contradiction of past ideas on the subject. Also of interest is the relatively poor response to F.Y.M., which, though it often (but not always) increases yields, does not do so as markedly as the fairly small dressings of nitrogenous fertilizer used. It is probable that the manure itself is often low in nutrients, particularly nitrogen, and should be used in conjunction with 100 lb./acre S/A. Note that on poor soils and under bad management the issue of a high yielding hybrid does not necessarily guarantee high yields.

(c) Replicated district NP factorial trials

The programme of these trials was reduced during the season and will be discontinued in future until the Agroecological Survey has been completed and the site definitely related to the soil series described. Six more trials were however conducted in Central Province and nine more in the Southern Province. For the Northern Province the results of past trials, of which a summary is given below were related to the soil series so far described by Dr. Young.

by R. Brown, Agronomist

by R. Brown, Agronomist

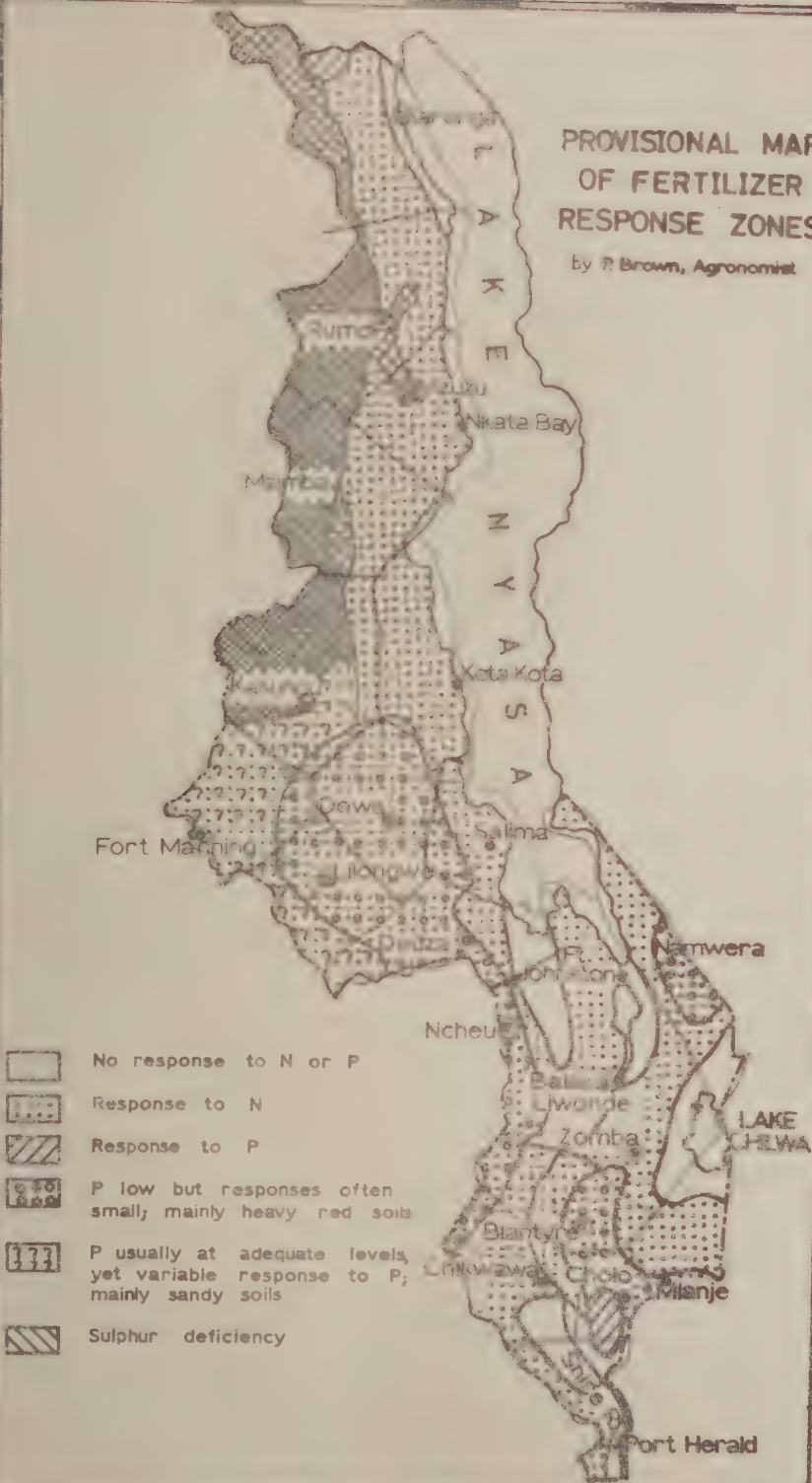


TABLE IX

Summary of responses to fertilizer on Soil Series of N. Province

Variety: Local

Yields: lb./acre grain

Soil Series		Brief description	Sulphate of Ammonia			Superphosphate		
			Nil	100 lb./acre	200 lb./acre	Nil	200 lb./acre	400 lb./acre
MZIMBA								
Loudon	(3)	Red Br. S.C.L. Sulphur may be short	1,420	2,090	2,400	1,340	2,480	3,060
Mpherembe	(5)	Dk. Br. S.L. to L.S. Acid. S. deficient	1,410	2,350	2,900	1,870	2,470	2,600
Bulala	(2)	Gr. Br. S.L. acid. S. deficient	1,170	2,260	2,940	1,850	2,230	2,300
Kafukule	(3)	Dk. Br. S.L. to L.S. Acid and gravelly	1,510	2,040	2,270	1,870	2,050	—
Jendalala	(2)	Dk. Red Br. S.C.L.	810	1,360	1,750	1,170	1,330	1,420
Ekwendeni	(2)	Red Br. S.C.L. to S.C.	1,910	2,640	3,160	2,510	2,630	2,600
RUMPI								
Rukuru	(7)	Dk. Br. to Black S.C.L. Valley bottoms (Nsangu) May waterlog	2,450	3,290	3,630	2,940	3,160	3,130
Rumpi	(4)	Dk. Br. S.L. to L.S. May be S. deficient	3,400	3,640	3,730	2,950	4,090	4,620
Kapemba	(3)	Dk. Gr. Br. S.L. May waterlog	1,730	1,960	2,540	1,900	1,980	2,260
Nchenachena	(1)	Dk. Red Br. S.C.L. Acid	1,580	2,530	2,890	1,660	2,570	2,770
KARONGA								
Chinunka	(4)	Dk. Br. S.C.L.	1,700	2,440	3,170	2,210	2,560	2,560
Fort Hill	(1)	Dk. Br. S.L.	2,440		3,010	2,420	3,040	—
Wenya	(1)	Dk. Grey S.L. Acid and gravelly	1,230	1,780	1,930	1,390	1,710	1,840
Karonga	(3)	Dk. Gr. Br. S.L. to S.C.L. May waterlog	2,540	2,670	2,790	2,710	2,620	2,660

Figures in brackets refer to the number of trials meant to give the above figures.

From this it will be seen that most of the soil series best suited to arable farming respond well to nitrogen and many give responses to added phosphate. Only Karonga lake shore series are unresponsive. Sulphur may be deficient on a number of series, but these are also short of nitrogen and often phosphate as well, and both the fertilizers normally used to remedy these deficiencies contain enough sulphur to supply the needs of subsequent crops.

CULTIVATION TRIALS

1. TIME AND METHOD OF PLANTING OBSERVATION, CHITEDZE

Duplicate plots of four methods of planting maize were planted at a series of different dates chosen to fall as nearly as possible just before, just after and two or three days after the early storms with which the rains usually break in the latter part of November. The object was to see which of the methods of planting gave the best yields at each date, and how the yield differences, if any, were brought about. Planting methods were:

- (a) Shallow planting (less than 1") with a stick (seeds lying on top of each other).
- (b) Deep planting (over 1") with a stick (seeds lying on top of each other).
- (c) Deep planting (over 1") with hoe (seeds lying side by side).
- (d) Shallow planting (less than 1") with hand (seeds lying side by side).

Three seeds were planted in hills spaced 3 ft. apart on ridges, 3 ft. from crest to crest, and the plots were not supplied.

Plant counts were taken 7, 11 and 15 days after planting to check the progress of germination, monthly measurements of height and leaf number were made to check the rate of growth and frequent counts were made at flowering to get an estimate of the date of onset of tasselling and silking. Results obtained indicate that seed should be planted deep, i.e. 1" 2" under all normal circumstances, but that it makes very little difference whether the seeds are piled on top of one another or placed side by side. There is thus quite a lot of scope for personal preference. Method of planting affected yield through establishment and cob number, having no effect on size of plant or cob. Time of planting affects the yield in two ways. Firstly and most important there is a steady decline in yield potential as planting is delayed after the first rains. This decline results from a progressive decrease in plant size, leaf number and cob size. Tasselling is also made to occur later and later in the season. Secondly there is the relationship of the time of planting to the early rain-storms of $\frac{1}{2}$ inch or more. This affects the stand and cob number, but not plant or cob size, and can be remedied by early supplying of gaps. The best time to plant is within 48 hours of a heavy storm. Next best is to plant in dry soil shortly before a heavy storm. Worst is to plant in moist soil that is drying out after a storm that is followed by a week or more of dry weather, which quite often happens in November and early December. Seeds planted in this last manner are inclined to swell, not quite germinate and rot, whereas seeds planted directly after a heavy storm are able to germinate properly, put down roots and live on the residue of water in the soil for up to 10 days.

TABLE X
Effect of time of planting on size and yield of maize
Variety: Mthenga *Yields: lb./acre grain*

<i>Time of Planting</i>	<i>Yield/acre</i>	<i>Plants/acre</i>	<i>Barren plants</i>	<i>lb./cob</i>	<i>Shelling %</i>	<i>Mature height</i>	<i>No. of leaves</i>	<i>Date of tasselling</i>
24/11/60 On 1st rain ..	5,140	10,100	60	.681	80	120"	17	15/2
29/11/60 Wet; but drying	4,350	9,070	Nil	.638	79	123"	17	18/2
1/12/60 Moist then dry ..	2,820	7,200	360	.549	73	115"	16	23/2
5/12/60 Dry planted ..	3,880	8,290	Nil	.599	74	111"	16	2/3
12/12/60 After heavy rain	4,210	10,220	540	.582	74	110"	16	3/3
17/12/60 Moist then dry ..	2,730	7,200	300	.530	76	98"	15	7/3
20/1/61 } Soil always	1,750	10,100	2,780	.363	68	85"	11	18/4
27/1/61 } adequately moist	1,450	8,950	2,360	.335	66	85"	12	22/4
4/2/61 }	660	8,590	4,600	.251	64	78"	11	28/4

Variety Trial

Location: Bvumbwe.

Object: To compare four West Indian varieties with one locally selected strain and one local hybrid in a high rainfall area.

Layout: 6×6 Latin Square.

Varieties were *Synthetic 13* and the hybrid *Mthenga* from Nyasaland, *Farm Corn*, *Haitian Yellow*, *Early Caribbean* and *Cuban Flint* from the West Indies. The experiment was planted on the 13th December which was about three weeks late; as a result yields were low, ranging from 1,455 to 2,133 lb. grain per acre but there was no significant difference between the yields of the local or the West Indian varieties. The local varieties are preferred because of the better-covered cobs, reducing the risk from weevil damage when stored on the cob.

OTHER CEREALS

Sorghums

1. SORGHUM FERTILIZER PLOTS, CHITALA

Duplicate plots of the recently imported Red K₂ sorghum, favoured for the brewing of African beer, were planted at 3 ft. × 2 ft. × 2 plant spacing and fertilized with O, N, P and NP fertilizer. N was a 200 cup of S/A per hill, i.e. approximately 350 lb./acre S/A. P was applied at the same rate i.e. approximately 300 lb./acre super. Bird damage was fairly heavy (shelling per cent. 63) and the yield was not very high, but there were marked responses to both fertilizers. *Striga* infestation was also considerable.

O—480 lb./acre grain		
N—715	"	"
P—760	"	"
NP—865	"	"

2. SORGHUM VARIETY OBSERVATIONS, FORT JOHNSTON

Six varieties grown in the lower Shire Valley were tested out on the Fort Johnston lake shore in single replicate observation plots at six sites. The crop was grown at 3 ft. × 2 ft. × 3 plant spacing.

From Table I it would appear that Kaswabanda and Melawanyumba are the best long term varieties. Kabuthu being a possible short term brewing sorghum. The sorghum did not grow well on soil lighter than sandy loam, and the heavier soils are such that given an adequate rainfall maize will give twice or thrice the yield of the sorghum. More information on rainfall reliability is needed before sorghum is encouraged to the exclusion of maize.

Bulrush Millet

A fertilizer trial on bulrush millet of mixed Nigerian variety was grown near Chikwawa in the Lower Shire. The crop was planted on 28th November in hills spaced 3 ft. × 1½ ft. and half the plots received a dressing of 200 lb./acre S/A on 12th December. Though there was a visible improvement in growth in the fertilized plots, there was very little difference between treatments at harvest, the mean yield being 1,980 lb./acre seed. Nitrogen appeared to increase the size of leaves and stem, but had no effect on seed.

TABLE I
Yield of Sorghum varieties in Fort Johnston District

Varities: Various

Yields: lb./acre seed

Instructor and Site		Soil type	Mcilawa-nyumba	Kaswabaada	M'nomkoo	Musoa-naal-ten	N. n. n. n.	Mulopa-gan	Mean
Zelewende, Fort Johnston	..	..	2,920	1,415	890	1,825	1,095	640	1,465
Mitawa, Mkhope Hill	..	..	2,360	3,630	2,205	735	1,125	1,130	1,870
Mtalika, Makanjila	..	..	965	1,185	185	170	500	290	545
Kaipa, Makanjila	..	..	1,760	2,605	755	1,210	1,615	1,775	1,620
Mdoka, Chimwala	..	..	—	1,470	725	1,050	1,090	1,290	1,125
Balakazi, Nangapoché	..	..	490	740	360	325	1,505	325	625
Maturity period	..	..	Long	Long	Long	Short	Short	Long	
Height	..	..	Very tall	Tall	Very tall	Very tall	Medium	Very tall	
Grain colour	..	..	White	White	Brown	White	Brown	Brown	
Head type	..	..	Open	Goose-neck	Open	Goose-neck	Goose-neck	Open	
Bird damage	..	..	Little	Little	Bad	Little	Little	Bad	
Flavour	..	..	Good	Good	Good	Good	Bitter	Good	
Mean yield	..	..	1,690	1,915	880	855	1,170	840	

Extract from Report of the Plant Pathologist

BULLRUSH MILLET. *Sclerospora graminicola* (Sacc) Schroet, the cause of downy mildew of Bullrush millet, has appeared again, but so far restricted to the higher, wetter, areas where millets are not important economic crops. It was reported in the 1938 Annual Report.

Rice

1. NITROGEN AND TIME OF APPLICATION TRIAL, KAPORO

A fertilizer trial at Kaporo, on North Karonga lake shore, was conducted using Faya rice and three levels of sulphate of ammonia applied either at planting on 20.1.60 or top dressed one month later 23.2.61. The design was a 3×3 factorial with 2 replications as in past years. On this site there were no significant differences in yield, and though there appears to be an increase of between 10 and 15 per cent. as a result of applying 400 lb./acre S/A to the seed bed, top dressing caused lodging with consequent loss of yield. Yields were fair to good.

TABLE II
Response to S/A by rice at Kaporo, Karonga
Variety: Faya *Yields: lb./acre paddy*

<i>Applied to seedbed</i>				<i>Nil</i>	<i>200 lb. S/A</i>	<i>400 lb. S/A</i>	<i>Mean</i>
<i>Top dressed</i>							
<i>Nil</i>	..	..	..	1,990	2,090	2,170	2,080
<i>200 lb. S/A</i>	..	..	..	1,950	2,080	2,220	2,080
<i>400 lb. S/A</i>	..	..	..	1,610	1,500	1,740	1,620
<i>Mean</i>	..	..	..	1,850	1,890	2,050	1,930

L.S.D. 5% marginal means .. 480 Coef. Varn. 18.3%
L.S.D. 5% centre table .. 830

2. CULTIVATION TRIAL, MWENETETE

This was the fourth and final year of this trial on the same site. The design is a $2 \times 2 \times 3$ factorial, with 2 main treatments per block split into 6 sub-treatments on each. Treatments are:

- C₁—Plough immediately after harvest.
- C₂—Leave ploughing until after the onset of the rains.
- T₁—Sow at the beginning of January.
- T₂—Sow at the beginning of February.
- S₁—Broadcast dry seed.
- S₂—Broadcast pregerminated seed.
- S₃—Transplant.

The soil is dark grey sandy clay loam of the Mwenetete series and is quite well supplied with plant foods. Limiting factors to the yield of rice are almost certainly water control and weed control.

It would thus appear from Table III that under uncontrolled flood conditions one should broadcast dry seed in early January, having ploughed the land directly after the previous harvest and put in as many weed killing cultivations as possible before sowing. Transplanting is not to be recommended unless the water can be controlled.

TABLE III
Effects of cultivation and planting treatments on rice yields

Variety: Faya

Yields: lb./acre paddy

Treatments	Yield/acre					Sample of monocot. weeds					Mean %
	57.58	58.59	59.60	60.61	Mean	57.58	58.59	59.60	60.61	Mean	
S ₁ Broadcast dry	1,130	3,280	1,200	2,790	2,120						
T ₁ Early January	900	Not comp.	1,420	2,900	1,740	199	449	380	189	109	
T ₂ Early February	1,350		1,170	2,680	1,730	105	210	200	210	61	
S ₂ Broadcast pre-germinated	390	2,810	1,480	2,540	1,800						
T ₁ Early January	310	Not comp.	1,510	2,380	1,400	220	500	320	280	111	
T ₂ Early February	470		1,430	2,700	1,540	133	223	180	180	60	
S ₃ Transplant	410	2,360	1,190	1,090	1,260						
T ₁ Early January	600	Not comp.	490	850	650	250	700	570	840	198	
T ₂ Early February	230		1,880	1,520	1,140	313	400	280	410	115	
C ₁ Plough after harvest	620	3,210	1,490	Not comp.	1,770	540	1,050	890	Not Appr.	100	
C ₂ Plough after first rains	670	2,410	1,150	Not comp.	1,410	300	1,270	1,000		116	
Mean	650	2,810	1,320	2,140					Mean yield/acre		
Coef. Var.	46.5%	34.2%	28.5%	21.6%			Treatment				
L.S.D. 5% S.	220	490	270	330			T ₁ Early plantings		1,260	100	
L.S.D. 5% TS.	310	—	380	470			T ₂ Late planting		1,470	58	
L.S.D. 5% C & T.	180	540	220	—							

Extract from Report of the Entomologist

RICE

A Hispid beetle (*Trichispa sericea* Guer.) was first discovered attacking rice in Zomba District in February, 1961. This is apparently the first Nyasaland record of this rice pest that is locally serious in other parts of Africa, and which caused serious damage in Swaziland in 1954-55.

T. sericea has been recorded to date only in the Shire Highlands and so far has caused only local damage. The adults feed on the leaves while the larvae mine the leaves and pupate in the tunnels. There are a number of wild graminaceous hosts. Malathion has shown promise as a control.

OIL SEEDS

Groundnut Variety Trials

1. GROUNDNUT VARIETY TRIALS, CHITEDZE AND CHITALA

Randomized block variety trials were held at both Chitedze on red brown sandy clay loam and at Chitala on dark grey sandy clay. At Chitedze there were seven replications of twelve varieties and at Chitala, five replications of six varieties. Yields and oil contents are given below.

TABLE I
Yields of Groundnut varieties on Central Plateau and Lake Shore

<i>Variety: Various</i>					<i>Yields: lb./acre shelled nuts</i>			
<i>Variety</i>				<i>Type</i>	<i>Chitedze (3,770 ft. a.s.l.)</i>		<i>Chitala (1,900 ft. a.s.l.)</i>	
					<i>Yield</i>	<i>Oil content %</i>	<i>Yield</i>	<i>Oil content %</i>
Mani Pintar				B.L.	2,380	49.7	2,380	53.1
Amani				R.L.	2,160	48.1	1,550	49.4
Mwitunde				B.L.	1,840	47.1	1,500	46.0
Early Runner				R.M.	1,600	47.7	1,950	50.7
Dixie Runner				R.L.	2,100	49.9	1,410	51.3
A.R.S. Spanish				B.E.	1,610	49.7	1,560	49.5
Gambia				B.E.	1,440	48.1	—	—
Konyoma				R.L.	1,800	49.6	—	—
U/A 34				R.L.	2,000	48.6	—	—
Chalimbana				R.L.	1,780	48.3	—	—
Buyaya				R.L.	1,690	46.4	—	—
Karonga				R.L.	1,740	48.5	—	—
L.S.D. 5 per cent.					230	—	280	—
Mean					1,845	48.7	1,730	50.0
Coef. Varn.					11.7%	(first six)	12.2%	

Mani Pintar has given the highest yield of shelled nuts and oil at both stations as it did last year. At the higher altitude Amani, Dixie Runner and U/A 34 were runners up, giving yields appreciably above the present standard, Mwitunde. On the lake shore at Chitala, Early Runner was the only other variety to rise well above the standard, but it showed a tendency towards having weak pegs at harvest, being an early maturing type. Oil contents show again the past trend towards higher percentages at the lower altitudes. Provided that the white and red seed colour is no drawback the high yield potential of Mani Pintar may well put it into competition with the established varieties.

2. GROUNDNUT VARIETY TRIALS, NORTHERN PROVINCE

4×4 Latin square experiments were conducted at four sites in the Northern Province to compare Mani Pintar with established varieties. At all sites it produced the best stands and the highest yield.

TABLE II
Yields of Groundnut Varieties in Northern Province

Variety: Various				Yields: lb. /acre shelled nuts							
Variety				Mbawa 4,000 ft. a.s.l.		Jenda 4,700 ft. a.s.l.		Pharasiwe 3,600 ft. a.s.l.		Baka 1,590 ft. a.s.l.	
				Yield	Plants/ acre	Yield	Plants/ acre	Yield	Plants/ acre	Yield	Plants/ acre
Amani (Obs.)	..	..	1,345	32,170	—	—	—	—	—	—	—
Mani Pintar	..	..	1,285	26,780	905	30,470	525	13,040	1,670	—	—
Mwitunde	..	..	800	22,490	665	27,690	380	10,400	790	—	—
Dixie Runner	..	..	1,165	27,420	505	23,760	270	6,960	980	—	—
Local	..	..	1,065	28,600	395	18,400	350	9,680	630	—	—
L.S.D. 5 per cent.	..	..	175	—	190	—	145	—	380	—	—
Mean	..	..	1,105	—	620	—	380	—	1,020	—	—
Coef. Varn.	..	..	9.1%	—	19.5%	—	21.6%	—	21.8%	—	—

Groundnut Fertilizer Trials

1. RATE OF APPLICATION OF GYPSUM, NORTHERN PROVINCE

Nine simple experiments were conducted at various sites in Northern Province to determine the optimum rate of application of gypsum to control sulphur yellows. Four rates of application were replicated six times at each site. Unfortunately at many of the sites there was no response, as in the absence of the Experimental Officer on leave, the experiment was put on pieces of land which had received S/A applied to the maize crop in the previous season.

TABLE III
Effect of rates of Gypsum on Groundnut yields

Variety: See below			Yields: lb./acre shelled nuts						
Site		Previous Crop	Rates of Gypsum/acre				L.S.D. 5%	Mean	Coef. Varn.
			Nil	50 lb.	100 lb.	200 lb.			
Mbawa (Mz.)	..	Rhodes grass) (no fert.)	955	980	1,025	1,020	105	995	8.7%
Bulala (Mz.)	..	Beans (no fert.)	550	620	590	540	150	575	20.7%
Jenda (Mz.)	..	Maize + S/A	520	530	580	560	120	550	17.6%
Maridade (Mz.)	..	Maize + S/A	800	760	720	920	290	800	29.9%
Euthini (Mz.)	..	Not recorded	560	490	420	410	170	470	28.9%
Levi Jere (Mz.)	..	Not recorded	900	1,030	970	950	210	960	17.6%
Manyamula (Mz.)	..	Not recorded	280	260	310	290	50	285	15.4%
Katumbi (Ru.)	..	Bush	1,270	1,730**	1,820**	2,000***	290	1,550	12.8%
Ng'onga (Ru.)	..	Bush	1,070	1,120	1,240*	1,430***	140	1,210	9.2%

2. NITROGEN AND PHOSPHATE OBSERVATION, CHITEDZE

On a red brown sandy clay loam of Lilongwe series with pH=5.5, total N=0.140 per cent., available P=7 p.p.m. and K=0.30 m.e. per cent. there were no responses to direct applications of either phosphate or nitrogen.

Nil	..	..	..	1,115 lb./acre kernels
200 lb. Supers	..	..	..	1,110 lb./acre kernels
200 lb. Supers + 200 lb. S/A	..	..	..	990 lb./acre kernels

Superphosphate was applied as a band in the ridge before planting and the sulphate of ammonia was top dressed in a band on the ridge top a month after planting.

3. RESIDUAL FERTILIZER TRIAL, MBAWA

In this trial, 200 lb. supers, 200 lb. S/A, 100 lb. urea and 300 lb. gypsum were applied in various combinations to groundnuts grown in the 1958-59 season. There were large responses to sulphur-containing fertilizers, and these responses also appeared in a maize crop grown on the residual effects of the fertilizers in 1959-60. This year however a groundnut crop, planted late, showed no residual effects remaining. Yields were low, 410 lb. acre shelled nuts, and the Coef. Var. was 14.8 per cent.

Groundnut Cultivation Trials

1. SEED TREATMENT TRIAL, CHITEDZE

A 4×3 factorial trial with four replications was planted at Chitedze to test the effect of seed treatment with Agrosan (organic mercury), Fernisan (T.M.T.D.) and Agrocide (B.H.C.) on the germination, growth and yielding capacity of Mwitunde seed freshly shelled by hand or machine from the crop just lifted, and on hand shelled seed which had been in store for 15 months. A control plot of unshelled seed was also planted in each block. Planting rains were excellent and there was no difference at all between stand and yield of the shelled treatments. The unshelled seed gave only 85 per cent. of the stand of the other treatments but its final yield was less than 100 lb. shelled nuts lower than the others. Mean yield was 1,400 lb. acre shelled nuts and Coefficient of Variation 12.1 per cent. Under such conditions seed dressing was certainly not worth while and the labour of shelling the seed for planting was hardly worth it.

Sesame

A time and method of planting trial with sesame was conducted at Baka, Karonga, on dark grey sandy loam of the Karonga series. The design was a $2 \times 2 \times 2$ factorial with four replications. The crop ripened very unevenly, shattered badly and gave poor yields. Nevertheless it appears that it pays to plant early, i.e. in December, not February, and that December plantings are best made on ridges. A 3 ft. $\times$ 1 ft. $\times$ 3 plant spacing gave slightly better yields than a 3 ft. $\times$ 2 ft. $\times$ 3 plant spacing.

TABLE IV
Time and method of cultivation of Sesame

Variety: Local				Yields: lb./acre seed		
Treatments				T ₁ Planted 15/12/60	T ₂ Planted 3/2/61	Mean C
C ₁	Ridge cultivated	..	..	425*	230	330*
C ₂	Flat cultivated.	..	..	275	230	250
Mean T	..	..	..	350**	230	290
S ₁	3 ft. $\times$ 1 ft. $\times$ 3 plants	..	..	310	L.S.D. 5% marginal means 65 Coef. Var. .. 30.4%	
S ₂	3 ft. $\times$ 2 ft. $\times$ 3 plants	..	..	270		

At Tuchila sesame drilled on 27th February on 3 ft. ridges and thinned to 1 plant every three inches gave 240 lb./acre seed when harvested on 27th June, and gave no response to added N. Hill planting of two plants every 12 inches in the row gave lower yields and a response to nitrogen. Planting could have been earlier.

Oil content of shrivelled and discoloured groundnuts

1. DISCOLOURED NUTS

An enquiry was made by the A.P.M.B. concerning the oil content of certain "discoloured" nuts which were appearing at markets and spoiling the appearance of samples. The Mwitunde or local type nut newly shelled has a pale pink testa which goes brown with the passage of time. The "discoloured" nuts were brownish, but were not mildewed or marked with dark streaks or dots. The oil content of "discoloured" nuts from three sources proved to be higher, if anything, than that of pink nuts from the same sample, which confirms the theory that these are merely fully matured nuts which have been shelled for some time—possibly since the previous season. In a dormant variety lifted late, the earliest formed nuts may have started to go brown by the time the crop is shelled.

Source	Pink nuts	Discoloured nuts (brown)
Mwitunde ex Chitedze, 1961	45.0	47.8
Dixie Runner ex Chitala, 1961	51.9	50.7
Local from Lilongwe District, 1961	46.5	48.2

Note that "discoloured" in this content does not refer to those nuts which are obviously suffering from fungus attack. These are also brown, grey or stained, but can be quite easily differentiated from the brown nuts referred to above.

2. SHRIVELLED NUTS

A further enquiry was made into the percentage and oil content of various grades of small and shrivelled nuts which can be screened out of the sample as shelled by hand. Samples of Mwitunde and Mani Pintar from Chitedze and samples of various qualities of local type nuts from markets in Lilongwe District were put through a standard series of home-made screens and the fractions analysed for oil. The screens were oblong holes punched in aluminium sheet with home-made dies. All holes were 1 in. long and their widths ranged from $\frac{3}{16}$ through $\frac{1}{8}$ and $\frac{7}{16}$ to $\frac{1}{4}$.

TABLE V
Percentage and oil content of various size grades in groundnuts

Sample and mark				Grade A Over 19/64		Grade B 19/64-17/64		Grade C 17/64-15/64		Grade D Under 15/64	
				% of sample	Oil %	% of sample	Oil %	% of sample	Oil %	% of sample	Oil %
<i>Chitedze</i>											
Mwitunde ..	..	..	..	63.0	47.2	27.5	46.7	5.7	42.8	3.2	—
Mani Pintar ..	..	..	..	77.9	49.8	18.4	49.5	1.6	45.2	2.1	—
<i>Mpingu (Local)</i>											
MU-4d ..	..	..	..	—	—	87.5	45.4	8.7	48.8	3.7	43.6
MU-5d ..	..	..	..	—	—	94.3	47.1	3.7	46.1	1.9	44.4
<i>Nambuma (Local)</i>											
NB MX S ..	..	..	..	—	—	92.3	45.8	3.8	41.8	3.8	38.4
NB MX ..	..	..	..	—	—	92.3	41.3	4.8	39.5	2.8	37.9
NB ..	..	..	..	—	—	89.8	43.0	5.9	38.3	4.3	36.6
<i>Lumbadzi (Local)</i>											
LM MX ..	..	..	..	—	—	86.1	44.7	7.8	42.0	6.1	37.1
LM ..	..	..	..	—	—	89.3	41.5	6.1	38.3	4.6	38.2
<i>Mkwinda (Local)</i>											
MW (1) ..	..	..	..	—	—	94.9	44.8	3.0	39.8	2.0	38.9
MW (2) ..	..	..	..	—	—	87.6	46.0	8.3	39.3	4.1	37.9
Average of Market Samples ..				—	—	90.5	44.4	5.8	41.5	3.6	39.2

The screens were two foot square, operated by hand by two men. Under these conditions two men with a suitable screen could sieve out the shrivelled nuts from about 150 lb. of hand shelled nuts per hour.

Oil content was found to decrease in nuts below $\frac{1}{4}$ grade, most of which would be shrivelled and immature. The oil content of the small grade was still considerable however.

Soya

Location: Bvumbwe.

Object: To select a higher-yielding variety for the Mixed Farm Unit.

Layout: Randomized block with eight replicates and fifteen varieties. Size of plot, 1/400th acre.

The trial was planted on 1st December with inoculated seed in ridges 3 ft. apart in two lines at a spacing of 6 in. by 6 in. and two seeds per hole. Soil was typical of that described for Bvumbwe. Varieties planted were *Volstate* (Tokyo X Pl. 54610) and *Pelican* (Tanloxi X Pl. 60406) from Texas, U.S.A., *Benares* from Nigeria; 54S70 51S137, 147 and 107 from Henderson Research Station, Southern Rhodesia; *Lee*, *Jackson* and *Hood* from United States via the Pig Industry Farm, Southern Rhodesia; 1558 (SHE. 120 or Hernon 237), 1557 (SHE. 112 or Glycine 29 ex Buitenzorg, Java), 1559 (SHE. 126 or Benares ex Nigeria), 1560 (SHE. 347 2 or Hernon variety) and 1554 (selected from S.10) all from Yangambi, Congo.

There was some damage from caterpillars and the elegant grasshopper. The varieties *Volstate*, *Pelican*, 54S70, 54S137, *Lee*, *Jackson* and *Hood* were harvested in March/April and the remainder matured early in June.

A small quantity of seed of *Lindarine* and *Ford* was received from the United States, but these varieties failed to germinate.

Soya Yields, Bvumbwe, 1961

Variety							lb. seed per acre
147	..	..	..	..	..	..	2,655
107	..	..	..	..	..	..	2,065
Hood	..	..	..	..	..	..	1,979
Volstate	..	..	..	..	..	..	1,864
Pelican	..	..	..	..	..	..	1,778
Lee	..	..	..	..	..	..	1,436
54S70	..	..	..	..	..	..	1,405
51S137	..	..	..	..	..	..	1,259
Jackson	..	..	..	..	..	..	1,209
1560	..	..	..	..	..	..	887
1554	..	..	..	..	..	..	856
Benares	..	..	..	..	..	..	720
1559	..	..	..	..	..	..	635
1558	..	..	..	..	..	..	554
1557	..	..	..	..	..	..	519
Mean	..	..	..	..	..	..	1,321

L.S.D. P=0.05 .. 250

P=0.01 .. 331

Coeff. of variation 19%

Although *Volslate* and *Pelican* still ranked among the best yielders, 147 was the only variety which produced over 10 bags to the acre which, it is reckoned, is necessary to make the production of soya profitable on the Mixed Farm Unit.

Varieties obtained from low latitudes (Congo and Nigeria) were the lowest yielders, and none were more outstanding than *Benares* in the production of green matter.

Extract from Report of the Plant Pathologist

Groundnuts. *Cercospora* leafspots: A survey of the incidence of *Cercospora* leafspots on an experimental plot in Zomba (alt. 5,000 ft.) supported evidence of the distribution of the two species of *Cercospora* involved, reported in Annual Report, 1956-57. It was found that *Cercospora arachidicola* Hori appeared as early as 20 days after planting whereas *C. personata* (B+C) Ell & Ev. did not appear until two months after planting. At this altitude most of the damage appeared to be due to *C. arachidicola*, *C. personata* doing relatively little damage. From a number of leafspot affected leaves selected at random, *C. arachidicola* was found present at the end of the season to the extent of 7 lesions/leaflet. It is likely therefore that at this altitude *C. arachidicola* causes more damage than *C. personata*. It is hoped to continue observations on the distribution of these leafspots over the Protectorate with a view to the production of economical control measures.

Rosette. Rosette incidence was very low during the year under review. 16 reputed rosette resistant varieties were planted in Zomba. Two of these developed rosettes: variety 488 ex Senegal, and variety A 1374 ex INEAC. The same 16 varieties have been planted again and will be observed through the coming season.

Extract from Report of the Entomologist

Hilda patralis St. (Issidae) was recorded again this season on groundnuts. Although no detailed investigations were made, the pest appeared to be of little consequence this season, and it was not recorded as numerous in any area except towards the end of the season in a few limited localities.

***Aphis craccivora* Koch.** This Aphid vector of Groundnut Rosette disease has been recorded on the following alternative hosts in Nyasaland during the past few years: *Vigna*, *Delonix*, *Catania*, *Crotalaria* and *Cassia* spp.; *Dichrostachys* sp., *Calliopsis* sp., and Kudzu Vine. The relative importance of these hosts is not known, and there are almost certainly others.

Some wild plants survive from dropped nuts or seed left in the ground after harvesting, and plants survive in suitable places out of season, while in some parts of the country a dry season crop of groundnuts is planted: some small, apterous, slow-breeding colonies of the aphids occur on these plants at times, and these carry over to the following season when climatic conditions again become suitable for multiplication at a time when the new crop is available.

OTHER LEGUMES

1. YIELD AND FERTILIZER RESPONSE OBSERVATION PLOTS

At Chitedze, Chitala and Tuchila a series of plots was laid out to measure the yield potential of various legumes and their response, if any, to fertilizer. At Chitedze each variety had three fertilizer treatments (O, P and NP) replicated three times, individual plots being 1/110 of an acre. At Chitala and Tuchila each variety had two fertilizer treatments only (O and P) in duplicate plots, individual plots being 1/40 of an acre. Phosphate was applied at the rate of 200 lb. acre single superphosphate in a band in the ridge before planting. Nitrogen was top dressed at the rate of 200 lb./acre S/A along the top of the ridge one month after planting.

TABLE I
Yields of various legumes at Chitedze, Chitala and Tuchila

Variety: See below

Yields: lb./acre seed.

Variety etc.	Fertilizer treatment			Mean	Dates of Planting and Harvesting	Diseases etc.
	Nil.	P.	NP			
<i>Bambara Groundnuts</i>						
Barotseland	1,440	1,520	1,690	1,550	14/12/60	
(Chitedze)					18/ 4/61	Clean crop
N. Rhodesian	1,430	1,480	1,660	1,520	14/12/60	
(Chitedze)					18/ 4/61	Clean crop
N. Rhodesian	1,560	1,280	—	1,420	17/12/60	
(Chitala)					19/ 5/61	Clean crop
Mbawa D.	940	720	—	830	17/12/60	
(Chitala)					19/ 5/61	Clean crop
<i>Bush Beans</i>						
Canadian Wonder	920	1,100	1,220	1,080	14/12/60	Three species of leaf spot, not serious
(Chitedze)					2/3-21/4	
Canadian Wonder	135	50	—	95	19/12/60	Poor, unthrifty crop
(Chitala)					17/ 3/61	
<i>Cow peas</i>						
Mwazisi	320	365	420	370	3/1 /60	Crop ruined by <i>Ascochyta</i>
(Chitedze)					23/3-21/4	
Local	Nil	Nil	—	Nil	17/12/60	Killed by <i>Ascochyta</i>
(Chitala)						
Guar (Cyamopsis)	400	450	—	425	17/12/60	Full bloom
(Chitala)					18/ 5/61	
<i>Soya Beans</i>						
Benares	1,365	1,450	1,345	1,390	14/12/60	Clean crop
(Chitedze)					23/ 5/61	
Malaya	1,260	1,360	—	1,320	7/ 1/61	Clean crop
(Chitala)					18/ 5/61	
Volstate	760	900	—	830	7/ 1/61	Clean crop
(Chitala)					1/ 5/61	
<i>Black Gram (Tuchila)</i>	100	90	—	95	23/ 2/61	Rather late planted
					23/ 6/61	
<i>Chick Peas (Tuchila)</i>	110	120	—	115	23/ 2/61	
					1/ 8/61	
<i>Dolichos (Tuchila)</i>	330	380	—	355	23/ 2/61	
					18/ 8/61	

All these legumes were planted on 3 ft. ridges with two rows per ridge. Bambarra groundnuts and bush beans should be hull planted at a 12 inch spacing within the row. The other crops are better sown in drills.

2. RESIDUAL EFFECTS OF A PRE-EMERGENCE SPRAY OF 2-4D ON THE GERMINATION OF LEGUMES

At Chitedze a plot of land was pre-emergence sprayed with 2 lb./acre a.i. 2-4D on 28/11/60. No crop was planted. Weed control until the beginning of January was quite good. Half the plot was then sprayed again with 2-4D at the same rate on 31/12/60. This application had no effect on grass weeds already established but killed the few dicotyledonous weeds. The plot was then skim weeded by hand and duplicate plots 1 row x 10 yds of five types of legume were planted on each half of the plot on 3/1, 14/1 and 23/1/61. The plots were recorded for germination percentage and yield. All the plots were hand cultivated and weeded on 27/1/61. The residual effects of the 2-4D were evident, and some differential susceptibility to the weed killer seemed apparent, see table II.

Though the experiment was not statistically accurate and the effect of late planting can be seen in the yield figures along with the effects being studied, it is evident that groundnuts, bambarra groundnuts and soya beans are more susceptible to the residual effects of 2-4D than cow peas or bush beans. Bush beans and cow peas can probably be planted within a week of a 2 lb./acre spray of 2-4D, while groundnuts and soya should be planted two weeks after the application and bambarra groundnuts must be kept out of the ground for a month or more. It is interesting to note that the small isolated and late planted plots of cow peas managed to evade the normally devastating attack of *Ascochyta* leaf spot and gave excellent yields.

TABLE II
Effect of 2-4D on percentage standard yield of various legumes
Variety: See below

Treatment			Planted	Weeks from Spraying	% Stand				Yield/lacre				
Sprayed					G. Nuts.	Bambarra Beans	Bush Beans	Soya	Cow Pea	G. Nuts.	Bambarra Beans	Bush Beans	Soya	Cow pea
1 } 28/11 2 } and 3 } 31/12	..	..	3/1/61	†	28	72	30	55	195	580	485	365	1,475
	..	..	14/1/61	2	32	97	93	91	895	555	555	240	1,065
	..	..	23/1/61	3‡	68	94	80	98	985	870	315	365	920
4 } 5 } 28/11 6 }	..	..	3/1/61	5	79	85	86	70	980	2,010	435	1,015	895
	..	..	14/1/61	6‡	93	92	97	95	845	1,600	510	240	980
	..	..	23/1/61	8	92	91	89	94	265	1,140	145	485	750

TOBACCO

Dark Fire-cured Tobacco

All experiments have been carried out at Chitedze Agricultural Research Station, Lilongwe, on red-brown sandy clay loam over sandy clay soils. Nitrogen and potassium levels are only moderate and phosphate status is very low. Topsoil acidity ranges from pH 5.6 to 6.1.

The quality of this year's crop, as measured by grade index, has been satisfactory. *Alternaria* began to spread in March due to late rains, and later planted experiments were affected.

1. VARIETY TRIAL

As previous trials have shown little or no difference between the wide range of varieties tested, these were limited to six this year, and a time of planting factor introduced. For the first time parent seed which will produce seed for trust land next year has been tested before being bulked. One new imported variety, HSD. 504, was introduced into the trial as a result of favourable growth in observation plots. The time of planting factor was introduced to see if quality of any variety was affected by differing climatic conditions, particularly after topping. The design was randomized blocks with six replications and plots split for time of planting. A basic dressing of 200 lb. "C" mixture (5:15:12) and 200 lb. sulphate of ammonia per acre, was applied to all plots.

TABLE I
Dark Tobacco Variety Trial at Chitedze—Two Times of Planting

Variety	Yield lb./acre	Grade Index	Crop Index	Per cent. Wrapper
<i>(a) Varieties</i>				
Toleza 58	1,162	47.7	55,414	2.28
Toleza 59	1,119	49.1	51,913	1.69
1960 selections	1,130	45.8	51,707	0.80
A.R.S. 53	1,067	42.9	45,747	1.71
Greenwood	1,074	41.1	44,116	1.39
H.S.D. 504	1,052	38.5	40,515	0.48
L.S.D. (P=0.05)	122	4.0	—	1.27
Coeff. of Variation	13.2%	10.8%	—	108.1%
<i>(b) Time of Planting</i>				
14th December	1,140	43.8	49,896	1.41
28th December	1,062	44.6	47,298	1.38
L.S.D. (P=0.05)	60	2.1	—	0.53
Coeff. of Variation	11.4%	9.8%	—	79.0%
Mean	1,101	44.2	—	1.39

There are no yield differences between varieties, but Toleza 58, 59 and the 1960 Selections gave better quality than Greenwood and HSD. 504, which are both imported varieties. Toleza 58 and 59 also gave significantly better quality than A.R.S. 53.

Planting on the 14th December, with the first main rains, improved yield but had no effect on quality.

The wrapper figures are of little value because of the high coefficient of variation.

Length-width measurements of the middle leaf left on the plant after topping and priming indicate that varieties A.R.S. 53, Toleza 59 and 1960 selections gave

shorter leaf than the other varieties when planted later. Delaying planting by two weeks reduced the length of the middle leaf from 29.4" to 28.4", but had no effect on leaf width.

2. TOPPING AND PRIMING TRIALS

Three 3×3 factorial topping and priming trials were planted at Chitedze at the end of November, mid-December and early January. It was thus hoped to cover the season adequately, and possibly pick out any over-riding climatic factor affecting quality. A panel of field officers advised on the range of the various topping and priming treatments, and these were fixed according to the appearance of the crop in the field, and whether the tobacco was early or late. The January planted tobacco was topped and primed low, but it subsequently made an unusual amount of growth for the time of year, due to late rains.

All experiments received 200 lb. sulphate of ammonia and 200 lb. "C" mixture per acre, and green leaf measurements were taken of the top leaf and the leaf at the tenth node on each plant. Top leaves from the first replication of each trial were labelled and measured after curing, thus showing what length grade the top leaf would be graded into. These measurements also allow experimental treatments to be translated into practical terms, for the benefit of field staff.

TABLE IIA
Topping and Priming Trial at Chitedze—Planted 29th November
Cured Leaf

Treatment	Yield lb./acre	Grade Index	Crop Index	Percentage Wrapper
(a) Topping				
Remove five leaves	920	54.6	50,250	4.6
Remove six leaves	976	54.7	53,403	4.3
Remove seven leaves	1,070	57.4	61,400	3.3
(b) Priming				
Harvest seven leaves	848	54.4	46,159	4.1
Harvest eight leaves	977	55.0	53,795	4.6
Harvest nine leaves	1,140	57.3	65,376	3.4
L.S.D. (P=0.05)	103	4.7	—	2.3
Mean	988	55.6	—	4.1
Coeff. of Variation	10.5%	8.4%	—	56.7%

TABLE IIB
Dimensions of Top Leaf

Treatment	Length in.			Width in.			Length/Width Ratio		
	At topping	At harvest	Cured	At topping	At harvest	Cured	At topping	At harvest	Cured
(a) Topping									
Topping 5 leaves	9.2	16.7	13.6	3.1	4.3	—	3.95	3.98	4.35
Topping 6 leaves	10.9	20.8	17.8	3.0	6.1	—	3.55	3.49	3.88
Topping 7 leaves	12.4	22.8	18.9	3.2	7.1	—	3.40	3.24	3.71
(b) Priming									
Harvest 7 leaves	10.8	20.4	17.4	2.4	6.0	—	3.61	3.65	3.81
Harvest 8 leaves	10.6	19.6	15.5	3.2	5.6	—	3.70	3.66	4.08
Harvest 9 leaves	11.1	20.5	17.4	3.8	6.1	—	3.59	3.50	3.92
L.S.D. (P=0.05)	1.4	1.3	—	0.5	0.5	—	0.23	0.13	—
Coeff. of Variation	12.5%	6.6%	—	16.8%	7.6%	—	6.3%	3.5%	—

Removal of seven leaves at topping, rather than five or six on this early planted crop improved yield without significantly affecting quality or wrapper percentage. This treatment also gave the longest and widest top leaf with the most satisfactory length/width ratio.

Harvesting nine leaves significantly improved yield without reducing quality or wrapper percentage.

TABLE IIIA
Topping and Priming Trial at Chitedze—Planted 20th December
Cured Leaf

<i>Treatment</i>					<i>Yield lb./acre</i>	<i>Grade Index</i>	<i>Crop Index</i>	<i>Percentage Wrapper</i>
(a) Topping								
	Remove seven leaves	..	..	..	1,094	55.2	60,310	6.3
	Remove eight leaves	..	..	..	1,152	53.9	62,154	3.9
	Remove nine leaves	..	..	..	1,234	50.3	62,098	2.2
(b) Priming								
	Harvest eight leaves	..	..	..	1,041	57.1	59,417	6.0
	Harvest nine leaves	..	..	..	1,219	52.0	63,384	4.2
	Harvest ten leaves	..	..	..	1,219	50.4	61,412	2.2
L.S.D. (P=0.05)					127	3.0	—	1.6
Mean					1,160	53.1	—	4.1
Coeff. of Variation					11.0%	5.6%	—	39.2%

Yield Interactions

Harvest

<i>Topping</i>					<i>Eight Leaves</i>	<i>Nine Leaves</i>	<i>Ten Leaves</i>	<i>Mean</i>
Seven leaves	..	..	..	..	1,043	1,045	1,192	1,094
Eight leaves	..	..	..	..	1,014	1,378	1,065	1,152
Nine leaves	..	..	..	..	1,067	1,234	1,400	1,234
Mean	..	..	..	..	1,041	1,219	1,219	1,160

L.S.D. (P=0.05) = 2.8

Wrapper Interactions

Harvest

<i>Topping</i>					<i>Eight leaves</i>	<i>Nine leaves</i>	<i>Ten leaves</i>	<i>Mean</i>
Seven leaves	..	..	..	..	10.4	5.4	2.9	6.3
Eight leaves	..	..	..	..	7.0	3.1	1.6	3.9
Nine leaves	..	..	..	..	0.6	4.1	2.0	2.2
Mean	..	..	..	..	6.0	4.2	2.2	4.1

S.D. (P=0.05) = 2.8

TABLE IIIB

Dimensions of the Top Leaf

<i>Treatments</i>	<i>Length (in.)</i>			<i>Width (in.)</i>			<i>Length/Width Ratio</i>		
	<i>At topping</i>	<i>At harvest</i>	<i>Cured</i>	<i>At topping</i>	<i>At harvest</i>	<i>Cured</i>	<i>At topping</i>	<i>At harvest</i>	<i>Cured</i>
(a) Topping									
Topping 7 leaves	12.2	21.2	18.5	3.8	6.8	4.8	3.33	3.24	3.88
Topping 8 leaves	13.8	22.5	20.6	4.4	7.5	5.9	3.17	3.07	3.47
Topping 9 leaves	15.4	22.8	20.6	5.2	7.9	6.4	3.04	2.95	3.23
(b) Priming									
Harvest 8 leaves	13.7	22.1	19.8	4.3	7.2	5.7	3.20	3.11	3.51
Harvest 9 leaves	13.8	22.6	19.8	4.5	7.5	5.6	3.16	3.10	3.54
Harvest 10 leaves	13.9	21.9	20.1	4.5	7.3	5.8	3.18	3.06	3.45
L.S.D. ($P=0.05$) ..	0.5	1.1	—	0.2	0.5	—	0.09	0.14	—
Coeff. of Variation ..	3.3	4.8	—	5.5	6.8	—	2.7	4.4	—

Topping seven or eight leaves on this tobacco did not significantly affect yield but did significantly improve quality whilst topping seven leaves gave significantly more wrapper leaf.

The length/width measurements indicate that the range of topping treatments in this experiment did not affect the length grade. Therefore, the significant differences in Grade Index reflect actual differences in leaf quality, not just upgrading on length.

Harvesting eight leaves rather than nine or ten resulted in a lower yield, but improved quality and wrapper percentage.

The interaction tables show that the combination of low topping and harvesting most leaves will give the highest yields, but high topping and harvesting the least number of leaves gives the highest percentage of wrapper leaf.

TABLE IVA

*Topping and Priming Trial at Chitedze—Planted 9th January**Cured Leaf*

<i>Treatment</i>		<i>Yield lb./acre</i>	<i>Grade Index</i>	<i>Crop Index</i>	<i>Percentage Wrapper</i>
(a) Topping					
Remove seven leaves	..	1,248	36.6	45,657	2.1
Remove eight leaves	..	1,148	34.1	39,082	0.8
Remove nine leaves	..	1,278	32.3	41,211	1.3
(b) Priming					
Harvest seven leaves	..	1,143	34.7	39,662	2.2
Harvest eight leaves	..	1,231	36.2	44,606	1.1
Harvest nine leaves	..	1,299	32.0	41,535	1.0
L.S.D. ($P=0.05$) ..	..	160	5.7	—	0.6
Mean ..	..	1,224	34.3	—	0.9
Coeff. of Variation ..	..	13.1%	16.7%	—	82.1%

TABLE IVB

Dimensions of the Top Leaf

<i>Treatment</i>	<i>Length (in.)</i>			<i>Width (in.)</i>			<i>Length/Width Ratio</i>		
	<i>At topping</i>	<i>At harvest</i>	<i>Cured</i>	<i>At topping</i>	<i>At harvest</i>	<i>Cured</i>	<i>At topping</i>	<i>At harvest</i>	<i>Cured</i>
(a) Topping									
Topping 7 leaves	17.4	25.8	22.6	5.6	8.4	7.1	3.19	3.09	3.19
Topping 8 leaves	19.2	27.0	24.1	6.3	9.2	7.4	3.09	2.97	3.24
Topping 9 leaves	21.1	28.7	24.9	7.4	10.3	8.1	2.90	2.80	3.07
(b) Priming									
Harvest 7 leaves	19.1	27.8	24.3	6.3	9.4	7.6	3.07	2.97	3.2
Harvest 8 leaves	19.1	26.5	23.4	6.4	9.1	7.6	3.08	2.93	3.0
Harvest 9 leaves	19.4	27.3	24.1	6.5	9.3	7.5	3.03	2.96	3.2
L.S.D. (P=0.05) ...	0.9	0.8	—	0.4	0.5	—	0.11	0.10	—
Coeff. of Variation	4.5	3.0	—	6.8	5.5	—	3.6	3.5	—

None of the treatments had any effect on yield or quality and the wrapper percentages mean very little, due to the high coefficient of variation for this analysis. The lower topping treatment increased the length and width of the top leaf.

The treatments for this experiment were fixed assuming that the rainy season would end at the normal time. However, unseasonal rain in April favoured late planted tobacco, and accounts for the high yields and possibly the lack of response to the various treatments.

It is difficult to draw general conclusions from these three experiments. Due to the abnormality of the season the latest planted gave the highest mean yield. This is contrary to all previous experience, and is only likely to occur very occasionally. The quality, as shown by the mean grade index, was much lower than the earlier plantings.

In the first of the earlier planted trials it can be noted that none of the treatments affected grade index or wrapper percentage, although the mean grade index was in fact the highest of the three experiments. On this first planting, topping seven and harvesting nine leaves clearly gave the highest yield and crop index.

In the second planted trial, put in three weeks later, the treatments applied did affect grade index and wrapper percentage. The highest topping decreased yield, but particularly when associated with priming to leave eight rather than nine or ten leaves, it markedly improved the grade index and wrapper percentage, bringing the former up to the level of the best of the first planting.

3. NURSERY-FIELD TRIAL

Arising from the apparent response to seedbed fertilizers reported in the Annual Report Part II for 1959-60, this trial was repeated. The experiment was a 3×4 factorial with five replications. The seedbed treatments being: no fertilizer; 7.5 lb. "S" mixture (6:18:6) or 2.1 lb. sulphate of ammonia per 24 square yards of seedbed; and in the field: no fertilizer, or 200 lb. of sulphate of ammonia and 200 lb. single superphosphate per acre, singly and in combination.

TABLE V
Nursery Field Trial at Chitedze—Planted 30th December, 1960

<i>Treatment</i>	<i>Yield lb./acre</i>	<i>Grade B Index</i>	<i>Crop Index</i>	<i>Percentage Wrapper</i>
(a) Seedbed Fertilizer				
Nil	855	33.5	28,643	1.4
7.5 lb. "S"/24 sq. yds.	868	37.3	32,371	3.1
2.1 lb. S/A/24 sq. yds.	878	37.1	32,482	3.8
L.S.D. (P=0.05)	71.0	4.0		
(b) Field Fertilizer				
Nil	776	28.9	22,414	0.2
200 lb. S/A per acre	839	33.2	27,856	2.9
200 lb. single supers per acre	751	38.0	28,533	2.7
200 lb. S/A per acre }	1,102	43.7	48,178	3.9
200 lb. single supers per acre				
L.S.D. (P=0.05)	95	4.6	—	—
Mean	867	36.0	—	—
Coeff. of Variation	14.9%	17.4%	—	—

The results do not confirm last seasons findings; the application of seedbed fertilizers did not improve either yield or quality. Eyescores 52 days after planting showed that plants fertilized with compound "S" had made slightly better growth at this stage.

The responses to field fertilizers followed the expected pattern. Both yield and quality were very significantly increased by the application of sulphate of ammonia and single superphosphate together, although separately they had no effect on yield and only superphosphate improved quality.

4. NITROGEN, PHOSPHATE, POTASSIUM TRIAL

The object of this trial was to determine the effects of these three elements, particularly phosphate and potassium, on yield and quality. The treatments were nil, 150 and 300 lb. sulphate of ammonia and nil, 250 and 500 lb. single superphosphate per acre and nil, 60 and 120 lb. sulphate of potash per acre.

TABLE VI

Nitrogen, Phosphate, Potassium Trial at Chitedze—Planted 13th December, 1960

Yield in lb. acre

<i>Single Superphosphate</i>	<i>Sulphate of Ammonia</i>			<i>Mean</i>
	<i>Nil</i>	<i>150 lb./acre</i>	<i>300 lb./acre</i>	
<i>Nil</i>	700	728	869	732
<i>250 lb./acre</i>	793	1,093	1,095	972
<i>500 lb./acre</i>	703	1,096	1,084	1,016
<i>Mean</i>	765	994	961	907
L.S.D. (P=0.05) Main treatments	..	..	..	118
L.S.D. (P=0.05) Interactions	..	..	..	204
Coeff. of Variation	..	..	..	12.9%

Mean Grade Index

<i>Single Superphosphate</i>	<i>Sulphate of Ammonia</i>			<i>Mean</i>
	<i>Nil</i>	<i>150 lb./acre</i>	<i>300 lb./acre</i>	
<i>Nil</i>	38.84	41.34	37.74	39.31
<i>250 lb./acre</i>	37.62	45.84	50.18	44.55
<i>500 lb./acre</i>	43.72	50.33	54.23	49.43
<i>Mean</i>	40.06	45.84	47.38	44.43
L.S.D. (P=0.05) Main treatments	..	..	..	4.22
L.S.D. (P=0.05) Interactions	..	..	..	7.31
Coeff. of Variation	..	..	..	9.5%

Percentage Wrapper

<i>Single Superphosphate</i>	<i>Sulphate of Ammonia</i>			<i>Mean</i>
	<i>Nil</i>	<i>150 lb./acre</i>	<i>300 lb./acre</i>	
<i>Nil</i>	1.62	2.59	1.54	1.91
<i>250 lb./acre</i>	3.81	3.51	4.27	3.86
<i>500 lb./acre</i>	2.51	8.90	8.90	6.77
<i>Mean</i>	2.64	5.00	4.90	4.18
L.S.D. (P=0.05) Main treatments	..	..	..	2.26
L.S.D. (P=0.05) Interactions	..	..	..	3.91
Coeff. of Variation	..	..	..	53.7%

Neither superphosphate nor sulphate of ammonia applied alone produced a significant response in yield, grade index or wrapper percentage. However, a response is shown in both yield and quality when both fertilizers are applied together at the lower levels. Increasing the level of superphosphate, applied with sulphate of ammonia increased the quality, but not the yield at both the 150 and 200 lb. level of sulphate of ammonia. No responses to sulphate of potash were noted despite apparent low potash content of the soil.

It has been noted in previous experiments of this nature that there has been a lack of response to phosphate without nitrogen, but this is the first occasion when lack of response to nitrogen, without phosphate, has been shown.

The coefficient of variation of the wrapper analysis was so high as to make the results only indications of trends until tested further. It would appear that phosphate is the most important element influencing wrapper percentage.

Burley Tobacco

All experiments have been carried out at Chitedze Agricultural Research Station, Lilongwe, on red-brown sandy clay loam over sandy clay soils. Nitrogen and potassium levels are only moderate whilst phosphate status is very low. Topsoil acidity ranges from pH 5.6 to 6.1.

Comparatively little leaf long enough to go into the first length grade was produced this season. This is possibly due to the fact that the field was later ploughed than usual, and supplies of available nitrogen may have been marginal. It could also be due to the season itself. In spite of this, yields and quality have been maintained.

There has been an appreciable increase in the amount of "coloury" leaf in the crop, even though the rains were very late, and it seems likely that this is due to the fact that the incidence of Frogeye was slight and it was therefore possible to leave the leaf on the plant until it was fully matured.

Any leaf not accounted for in the presentation of the results as "red" or "coloury" was graded out as green or short X.

1. VARIETY TRIAL

Four of the varieties tested in 1959-60 were compared with two re-introduced cigarette type Canadian varieties, Briarvet and Mammoth Kentucky, which gave appreciable amounts of "coloury" leaf when last tested. The object of the trial was to compare these with the four standard varieties which tend to be heavy bodied, slow maturing, and what the Canadians call export or wrapper types. The varieties were planted both early and late to try to ensure that any early maturing varieties would not be at a disadvantage due to being cured at the wettest time of the year, when one cannot normally expect to cure out "coloury" leaf. The experiment was a 2×6 factorial, with six replications, and all plots received a basic dressing of 200 lb. "C" mixture (5:15:12) and 200 lb. sulphate of ammonia per acre.

TABLE VII
Burley Variety Trial at Chitedze

Variety				Yield lb./acre	Grade Index	Crop Index	Per cent. Coloury	Per cent. Red
(a) Variety								
Barnet Special	..	..	..	1,913	56.7	108,389	36.3	43.4
Stand Upright	..	..	..	1,855	57.8	107,253	29.6	50.9
Burley 1	..	..	..	1,825	49.7	90,665	27.7	44.9
Briarvet	..	..	..	1,665	54.2	90,249	46.8	35.4
Mammoth Kentucky	..	..	..	1,675	53.3	89,298	37.2	42.1
Green Briar	..	..	..	1,540	46.7	71,892	29.2	40.5
L.S.D. (P=0.05)	..	..	..	189	4.3	—	6.2	4.2
(b) Time of Planting								
December 14th	..	..	..	1,913	53.7	102,667	32.1	45.4
December 28th	..	..	..	1,578	52.4	82,760	36.9	40.3
Mean	..	..	..	1,746	53.1	—	34.5	42.9
L.S.D. (P=0.05)	..	..	..	109	2.5	—	3.6	2.4
Coeff. of Variation	..	..	..	13.1%	9.8%	—	21.7%	11.8

The results show that Barnet Special is still the best variety available to growers when yield, quality and amount of "coloury" are considered together. Barnet Special, Stand Upright and Burley 1 yielded significantly better than Green Briar, and Barnet Special also yielded better than Briarvet and Mammoth Kentucky. Green Briar and Burley 1 gave significantly poorer quality than the other varieties, whilst Mammoth Kentucky was poorer than Stand Upright.

Briarvet was outstanding in the production of "coloury" leaf. Barnet Special and Mammoth Kentucky did not differ from each other in this respect, but gave significantly more "coloury" than Stand Upright, Burley 1 and Green Briar. The varieties with most "coloury" leaf gave least "red" leaf.

Early planting appreciably increased yield, had no effect on quality, but reduced the amount of "coloury" leaf. The interactions between variety and time of planting were not significant, but there is a suggestion that the effect of late planting on yield is less marked with Stand Upright than any other variety. Late planting reduced the yield of Mammoth Kentucky by one-third.

2. NURSERY-FIELD TRIAL

Arising from the findings from similar trials last year on both "Western" and Burley tobaccos (*see* Annual Report Part II, 1959-60) this experiment was designed to see whether those results were due to some plants being older than others when transplanted. From experience it is known that shaded plants take longer to reach transplanting size than those that have been mulched, and similarly non-fertilized take longer than fertilized plants. Thus, when plants of the same size are planted out together, as in an experiment of this kind, they are not the same age.

The experiment was a $3 \times 3 \times 2$ factorial with six replications. Seedbed treatments were shade or mulch in all combinations with nil fertilizer, 5 lb. "S" mixture (6:18:6) or 1.44 lb. sulphate of ammonia (21 per cent. N) per 24 sq. yds. Superimposed in the field upon these six treatments were: no fertilizer, 150 lb. sulphate of ammonia, or 150 lb. sulphate of ammonia with 250 lb. single superphosphate per acre.

Plants in the nursery were sampled at six and eight weeks after sowing, and again at planting, weight of roots and leaf, plus stem, number of leaves, and height of plant being determined. Twenty-seven days after transplanting, and twenty-two days after fertilizing, samples were taken from the various treatments and the weights of roots and stems, plus leaves, obtained. Fifty-one days after transplanting the plots were scored for growth and general vigour.

The most important factor emerging from the seedbed treatments was the difference in time taken to reach transplantable size. The range was from eight weeks for mulched plants with "S" compound to 11 weeks for shaded plants not fertilized. The various measurements taken show that mulched plants grow and develop at a faster rate, particularly in the first six weeks, than shaded plants, and are always ready for transplanting sooner. Similarly, fertilized plants get off to a better start than those not fertilized. Once non-fertilized plants had reached the same size as those that had been fertilized, irrespective of whether they were shaded or mulched, they had the same number of leaves, were of similar height and similar green weight. The weight of root produced was, however, twice as much as for fertilized plants.

Sampling 27 days after planting showed that differences in root growth, resulting from seedbed treatments had been evened out, and where sulphate of ammonia and superphosphate had been applied together the dry weights of roots and leaves, plus stems, were double those of the other field treatments.

Eyescores confirmed that seedbed differences had been evened out, and showed that there was an appreciable growth response to both nitrogen and phosphate.

TABLE VIII

Nursery Field Trial at Chitedze. Variety Barnet Special—Planted 29th December, 1960

Treatments	Yield lb./acre	Grade Index	Crop Index	Per cent. Coloury	Per cent. Red
(a) Seedbed Fertilizers					
Nil	1,190	41.8	49,806	20.4	40.3
5 lb. "S"/24 sq. yds.	1,282	42.6	54,666	23.9	41.0
1.44 lb. S/A 24 sq. yds.	1,247	43.5	54,258	25.4	40.8
(b) Field Fertilizers					
Nil	926	37.9	35,077	16.2	39.7
150 lb./acre S/A	1,249	43.3	54,059	23.0	43.1
150 lb./acre S/A	1,544	46.8	72,327	30.5	39.3
250 lb./acre single superphosphate					
L.S.D. (P=0.05)	100	2.4		2.5	4.82
(c) Seedbed Covers					
Shade	1,271	44.6	55,909	23.7	41.1
Mulch	1,209	41.3	49,962	22.8	40.3
L.S.D. (P=0.05)	82	1.9		2.0	2.8
Coeff. of Variation	17.3%	11.9%	—	23.2%	17.9%
Mean	1,240	42.7	—	23.2	40.7

The grading figures show that the only response to seedbed fertilizers was an increase in the amount of "coloury" at the expense of low grade leaf. There was no difference in yield, "coloury" or "red" percentage between shade and mulch treatments and only a slight improvement in quality in favour of the shade treatment.

The improvements in yield, quality, and "coloury" from the field applications of sulphate of ammonia alone, and single superphosphate in the presence of sulphate of ammonia, are outstanding.

By way of conclusion it can be said that the results do not confirm the findings of 1959-60. The main value of the use of mulch and seedbed fertilizers would appear to be the reduction in the time taken to produce seedlings of a transplantable size. Mulch is also easier to manage than shade and may produce more transplantable seedlings from a given seedbed area.

The length of time the seedlings are in the nursery does not appear to be important, within the limits applying to this experiment.

On soils low in nitrogen and phosphate the application of fertilizer will give handsome returns.

The above comments on seedbed treatments apply to tobacco planted this season under ideal conditions, and results may differ when the plants have to withstand adverse conditions immediately after planting.

3. TIME AND RATE OF PHOSPHATE TRIAL

This trial was repeated to try to determine the optimum time to apply phosphatic fertilizer. As last year's results indicated that phosphate response on deficient soils may be influenced by time of planting, the plots were split for this factor. The design was a 3×4 factorial with split plots. Fertilizer levels were, nil, 250 and 500 lb./acre single superphosphate, and were applied at planting one week before and one and two weeks after planting. A basic dressing of 150 lb. sulphate of ammonia, and 80 lb. sulphate of potash was applied to all plots.

Eyescores, 56 and 54 days after planting the early and late planted plots, respectively, showed a response to both levels of fertilizer at both times of planting. On the early planted plots delaying application of phosphate appeared to have retarded growth, but none of the time of application treatments had any effects on the later planted tobacco.

TABLE IX
Time and Rate of Phosphate Trial at Chitedze

Treatments				Yield lb./acre	Grade Index	Crop Index	Per cent. Coloury	Per cent. Red
(a) Single Superphosphate (19% P_2O_5)								
Nil	..	..	..	1,434	43.3	62,109	20.4	45.6
250 lb./acre	..	..	..	1,337	42.9	57,298	21.8	42.4
500 lb./acre	..	..	..	1,488	45.4	67,514	25.3	44.0
L.S.D. (P=0.05)	..	..	..	111	2.1	—	2.7	3.01
(b) Time of Application								
One week before	..	..	..	1,410	43.6	61,476	22.7	43.1
At planting	..	..	..	1,407	44.8	63,033	24.0	43.7
One week after	..	..	..	1,443	43.3	62,481	21.5	44.3
Two weeks after	..	..	..	1,419	43.7	62,010	21.8	44.9
L.S.D. (P=0.05)	..	..	..	128	2.37	—	3.1	3.5
Coeff. of Variation	..	..	..	15.4%	9.2%	—	23.7%	13.5%
(c) Time of Planting								
13th December	..	..	..	1,608	45.9	73,863	24.7	43.4
29th December	..	..	..	1,231	41.8	51,422	20.3	44.6
L.S.D. (P=0.05)	..	..	..	59	1.8	—	2.1	2.4
Coeff. of Variation	..	..	..	10.0%	10.1%	—	21.3	13.2%
Mean	..	..	..	1,419	43.8	—	22.5	44.0

TABLE IXA
Two-way Table for Yield (lb./acre)

Time of Planting				Single Superphosphate (19% P_2O_5)			Mean
				Nil	250 lb. /acre	500 lb. /acre	
13th December	..	..	..	1,694	1,470	1,660	1,608
19th December	..	..	..	1,174	1,204	1,316	1,231
Mean	..	..	..	1,434	1,337	1,488	1,419

Marginal Means	Rate of Phosphate	L.S.D. (P=0.05)	..	..	111
Marginal Means	Time of Planting	L.S.D. (P=0.05)	..	..	59
Within the body of the table	Rate $\times$ Planting	L.S.D. (P=0.05)	..	..	101

Yield response appears to be related to time of planting, a positive response only being obtained with the later planted tobacco. The negative response to 250 lb. single supers on the early planted plot cannot be accounted for. At the higher level of application quality and the amount of "coloury" leaf were significantly improved.

Early planting gave the expected improvement in yield and quality and also increased the percentage of "coloury" leaf.

The time at which the fertilizer was applied had no effect on yield, quality or percentage of "red" and "coloury" leaf.

The apparently significant drop in percentage "red" on addition of 250 lb. superphosphate, must be disregarded as the "F" test for this experiment was not significant.

Extract from Report of the Agricultural Chemist, Chitedze

CHEMICAL ANALYSIS—GRADED BURLEY LEAF

Careful grading of Chitedze leaf on the basis of colour and body demonstrated that all leaf, but the heavy dark red grade had similarity in chemical composition regardless of colour. The results given in Table I below are the means of four replicates.

TABLE I

Chemical Composition of Burley Leaf on the basis of Colour and Body (100% dry matter basis)

Grade	Per cent. Ash	Per cent. Alkaloids	Per cent. N	Per cent. P	Per cent. K	Per cent. Sugars
2C light body light colour ..	21.81	3.22	2.97	.40	5.00	4.58
2 Tan light body light colour ..	22.48	3.67	2.96	.31	4.78	4.01
2R light body red colour ..	21.76	3.36	2.99	.31	4.82	4.21
2R heavy body red colour ..	17.27	5.56	3.77	.35	3.65	5.14

LEAF SPOT IN THE TOBACCO NURSERIES, CHITEDZE

It was noted that the spotting was most pronounced on those beds without fertilizer and less so where sulphate of ammonia had been applied.

When "S" mixture (6:18:6) was present however no spotting occurred, and it was presumed that this was probably due to the higher phosphate content. Subsequent analysis the results of which are presented in Table II supported this contention.

TABLE II

Effect of "S" mixture on Tobacco Leaf Spot

Lab. No.	Type of Leaf	Treatment and Observations	Per cent. P
1579	Burley	Nil fert.—brown spotted	.11
1580	"	Nil fert.—white spotted	.10
1581	"	"S" mixture—no spotting	.23
1586	Dark-fired	Nil fert.—bad white spot	.07
1584	Dark-fired	S/Ammonia—light spotting	.10
1585	Dark-fired	"S" mixture—no spotting	.18

Extract from Report of the Senior Agricultural Chemist

TOBACCO (FLUE-CURED)

FERTILIZER RECOMMENDATIONS

In preparation for the 1960/61 season, 364 soils (184 top soils) from 45 estates were examined. This compared with 263 (181 top) in 1959/60. For the current (1961/62) season, 276 (146 top) samples have so far been analysed. Better control of nitrogen has brought about a general improvement in the territory's crop, and the need for the lower levels of nitrogen for Nyasaland's flue-cured tobacco, is demonstrated by the following breakdown of the 152 recommendations made.

lb. of N recommended	..	..	10 or less	10-12	12-15	15-20	20-25	25-30	30-35
No. of recommendations	..	..	68	17	20	18	17	9	3
Per cent. of total	..	..	44	11	13	12	11	6	2

Thus over half the recommendations were for less than 12 pounds of nitrogen per acre, and over 40 per cent. for 10 pounds or less. Only 19 per cent. of the fields required more than 20 pounds of nitrogen.

Nitrogen requirements calculated from mineralizable nitrogen have agreed with those made on the basis of the total nitrogen/texture relationship, discussed in the 1957/58 report, in 60-70 per cent. of the recommendations, the margin of difference allowed in the comparison being five pounds. That based on mineralizable data is usually high where a discrepancy occurs. However in some instances, the nitrification data has revealed why previous recommendations on certain estates had tended to be on the low side. Whether soil texture or climate is the predominating cause is still being studied, as estate records require watching for several seasons before any firm conclusion can be reached.

CHLORIDE-UPTAKE EXPERIMENT

The amount of "slatey" leaf which occurred in the 1959/60 crop, led to an experiment to see whether this factor was related to the chloride content of the leaf. Chloride levels of nil, 15 and 50 lb. per acre were used, derived from 550 lb. "B" mixture, 550 lb. "V" mixture, and the latter supplemented by 60 lb. common salt (X). In each case 15 lb. sulphate of potash was also added. Three dates of planting, to cover dry and wet conditions, were used. Some 200 leaf samples were taken as the crop matured, and analysed for chloride content in the lamina (L) and midrib (M). Corresponding soil samples (Top T and Sub S) from the plots were examined for pH and soluble salts. The data is summarized in Table I, figures being on a dry weight basis.

TABLE I
Chloride Content of Tobacco Leaf

Samples taken 17th January							Samples taken 1st February					
Block I Planted 9th November												
Leaf No.	B		V		X		B		V		X	
	L	M	L	M	L	M	L	M	L	M	L	M
1 ..	.65	1.8	1.4	2.8	3.5	4.0						
5 ..	.13	1.3	.29	1.8	.36	2.0	.11	1.4	.15	1.6	.16	1.4
9 ..	.22	2.0	.48	1.4	.28	1.8	.12	1.8	.21	2.1	.18	2.1
12 ..							.18	2.1	.31	2.1	.24	2.0
Sol.												
Salts	T	S	T	S	T	S						
Per cent.	.06	.04	.05	.03	.08	.04						
Block II Planted 29th November												
1 ..	.32	2.0	.59	1.7	1.2	3.4	.33	.51	.12	.59	.50	1.6
5 ..	.23	.50	.28	.93	.52	1.2	.10	.74	.15	.15	.31	1.0
9 ..							.35	1.1	.39	1.6	.28	1.8
Sol.												
Salts	T	S	T	S	T	S						
Per cent.	.06	.03	.06	.03	.05	.04						
Block III Planted 16th December												
1 ..	.29	.71	.34	1.2	1.2	2.1	.06	.49	.15	1.3	.21	2.2
5 ..	.27	.68	.50	.83	.46	1.2	.11	.46	.15	.75	.42	2.7
9 ..							.11	.56	.17	.51	.48	2.4
Sol.												
Salts	T	S	T	S	T	S	T	S	T	S	T	S
Per cent.	.06	.03	.03	.03	.04	.03	.04	.03	.02	.02	.04	.03

These figures indicate that initial uptake is greater in the dry planted tobacco, even though this was examined ten weeks after planting compared with the Block III leaf analysed only five weeks after planting. The "X" (excess chloride) brought the

chloride content to 3.5 per cent. in the lamina of the first leaf. It may further be noted that leaf samples from Block I, taken on 17th December (i.e. 5 weeks after planting) contained 1.8, 2.5 and 3.1 per cent. chlorine in the lamina of the leaf from the B, V and X plots respectively. The corresponding figures for the midribs were, 3.2, 3.5 and 4.4 per cent. This fact when compared with leaf 5 and 9 on Block I confirms that chloride is not very mobile within the plant, and will stay within the leaf which is growing at the time of high chloride level in the soil. Also, from a comparison of the data relating to leaves 5 and 9 on Block I, and 1 and 5 on Block II it is seen that though the chloride may be high initially, due to high uptake under drier conditions, the proportion of chloride decreases as maturity is reached. The higher proportion of chloride in the midrib is noteworthy.

There is little difference in the soils data, taken at the time when the plants have grown to a reasonable stage, although it may be noted that samples taken on 16th December showed contents of .11, .10, .14 per cent. on the B, V and X plots of Block I. The corresponding figures for Block II were .03, .08 and .05 per cent. It was however clear from sampling trials of particular rows that reliable data was difficult to obtain due to fertilizer distribution factors.

The good and extended rains reduced greatly the value of this experiment, as the late dry spell, during which time it has been suggested chloride accumulates, did not occur. The amount of slaty leaf in the crop was also very slight. This contrasted with the higher amount in the 1959-60 crop. Representative leaf from that year's crop at Makoka was examined and the following data obtained for chlorine content.

					Lamina	Midrib
Early Reaping	..	..	..	..	1.02	2.69
Late Reaping	..	..	..	..	1.41	5.32

It will be necessary to repeat this experiment, although it may be noted that recently alternative explanations of slatiness have been proposed. Also in connection with the occurrence of higher amounts of slatiness in leaf in the 1959/60 crop, all the soil samples received prior to that season were re-examined for the soluble salt content. Of the 180 top soils, only 35 had a salt content greater than 0.03 per cent., and for most of these the figure was less than 0.07 per cent. Five only contained salts at a concentration of 0.10 to 0.30 per cent.

LEAF COMPOSITION AND INCIDENCE OF ALTERNARIA

The problem of *Alternaria* on the largest estate in the Kasungu area, has been investigated further and soils investigations in this matter are dealt with in the Chitedze section. Although it was not possible to combine these with corresponding leaf analysis, representative samples affected by *Alternaria* were taken for comparison with satisfactory leaf from the same fields. The disease appeared in sporadic form, and the problem would appear easier to solve if it was associated with any particular field or cultural practice. The results are outlined below.

<i>Alternaria affected</i>					N	P	K	Mg	N/P	N/K
I	..	..	..	..	1.8	.48	2.8	1.0	.37	.64
II	..	..	..	..	1.4	.36	2.8	0.6	.39	.50
III	..	..	..	..	1.7	.47	2.9	1.4	.36	.58
IV	..	..	..	..	2.1	.57	2.8	0.9	.27	.76
<i>Slight or no Alternaria</i>										
V	..	..	..	..	1.3	.30	2.8	0.5	.43	.48
VI	..	..	..	..	1.4	.43	3.6	1.1	.32	.38
VII	..	..	..	..	1.8	.44	3.8	0.4	.41	.45

These figures would suggest that, as found previously, the N/K ratio is of considerable importance, although it is seen as in II and V, this ratio overlaps for both groups. However where affected and non-affected leaf is taken from immediately adjoining areas, the difference is definite. For example, samples IV and VII were adjoining, and the *Alternaria* affected leaf adjacent to that from which sample VI was taken, had an N/K ratio of .49.

To overcome the late release of nitrogen which possibly causes the localized effects, a top dressing of phosphate and potash is therefore to be tried in a formal experiment.

Extract from Report of the Plant Pathologist

Tobacco

Anthracnose. During the 1960-61 season, *Anthracnose* appeared for the first time on African grown tobacco in the Central Province. The outbreak occurred in an area bordering Portuguese East Africa, and it is thought may have been introduced on infected scrap from across the border. Affected seedbeds were destroyed, and all remaining beds within the immediate area sprayed to the end of the season. The disease did not reappear, and it is hoped that prompt action may have prevented its spread. In the Southern Province the disease appeared on ten estates.

Brown leafspot caused by the fungus *Alternaria longipes* (Ell & Ev) Mason was widespread during the year, occurring in greater quantity in the Southern Province than has been known before. A dry period in January was succeeded by a long wet spell during which the leaf ripened slowly. It is thought that this provided suitable conditions for the widespread development of the disease. In the Kasungu area the disease was less severe on a late planted, relatively high topped crop heavily fertilized with phosphates than on other crops in the area.

Scab caused by *Septomyxa affinis* again occurred sporadically in severe form in African areas in the Central Province. It is becoming apparent that in the conditions in which African farmers grow tobacco in the main Central Province growing areas, *S. affinis* tends to be more serious than has been thought in the past. It is responsible for considerable losses of seedlings and young plants in the nursery every year.

Bushy top virus was present in Virginia, Burley and Western tobacco and was serious in the Turkish tobacco crop in the Northern Province.

Extract from Report of the Entomologist

Heliothis armigera (American Bollworm) was reported as attacking ripe Turkish tobacco seed head in large numbers at Mbawa in April/May. This species occurred in considerable numbers on many hosts this season.

COTTON

Cotton Breeding (Makanga)

The four main lines of work continued and were as follows:

Selection within Albar 637 and related Albar 51's.

Selection within crosses between Albar 51 selections, introduced and local varieties.

WORK WITH NEW INTRODUCTIONS

A start has been made on the selection and breeding of a variety suitable for irrigation in the Elephant Marsh. For the second consecutive season at Makanga there was a complete absence of Bacterial blight (*Xanthomonas malvacearum*) despite fully susceptible varieties being grown. When culture was produced growth was well advanced and inoculation gave negative results.

The early production of culture from hot-house plants should overcome this difficulty in the coming season.

The station suffered the worst jassid attack recorded. Its effect on the large number of supplies made selection difficult.

ALBAR 51

Sufficient seed of A637 (4,094 tons) has been produced to completely replace CLB throughout the Protectorate.

Angular leaf spot was recorded in nearly all areas the symptoms being more obvious owing to extensive jassid damage. Seed samples have been sent to Namulonge to investigate any deterioration in the resistance to bacterial blight.

The eleven selections from the best four Albar 51 strains, including A637 were further listed with introduced varieties against the control.

TABLE I
Cotton Variety Trials
Lint Yields in lb. per acre

<i>Variety</i>	<i>Makanga</i>	<i>Ngabu</i>	<i>Chitala</i>
A637	262	286	373
CLB	266	247	281
ABC40	262	259	378
AC31	278	303	457
A(56)16	255	254	415
DIV	247	220	371
ABC31	238	310	413
A640	234	224	392
A(56)22	192	227	351
U.P.A.	312	307	489
A(56)23	175	292	422
A629	227	247	430
A367	94	286	369
104	211	284	387
122	289	285	404
132		365	370
136	304	427	455
158	342	376	427
246	301	390	398
262	262	347	508
271	233	319	421
273	269	339	416
282	316	385	499
347	316	357	450
Sign. Diff. (P=.05)	56	73	43
S.E.	±9	±13	±7
Reps.	6	6	6
Planted	8th Dec.	7th Dec.	

Nos. 282, 158, 136 have again outyielded A637.

A summary of their yields since 1958/59 is given in Table II.

TABLE II
Yield Summary
Albar 51 Single Plant Selections
Lint Yields in lb./acre

<i>Variety</i>	58/59	59/60		60/61			<i>Mean</i>
	<i>Makanga</i>	<i>Makanga</i>	<i>Ngabu</i>	<i>Makanga</i>	<i>Ngabu</i>	<i>Chitala</i>	
A637	365	324	558	262	286	373	361
A637(57)136	375	303	520	304	427	455	397
A637(57)158	525	333	953	342	376	427	432
A637(57)282	650	381	607	316	385	499	473

The Namulonge Albar A(56)23 and strain U.P.A.(56)5 have yielded better than A637 under sprayed conditions at Chitala. A further 17 plants have been selected for jassid resistance.

ALBAR CROSSES

Unselected F₃ populations of the 16 crosses between Albar 51 and four local and introduced varieties were again tested against A637, with contradictory results.

TABLE III

Albar Crosses Trial

Lint Yield in lb./acre

Variety				Ngabu	Makanga
A637	..	..	..	394	449
CLB	..	..	..	302	387
U.P.A.(56)5	..	..	..	422	404
AC31	..	..	..	465	504
509	..	..	..	279	408
513	..	..	..	261	360
514	..	..	..	266	430
516	..	..	..	313	351
518	..	..	..	259	424
519	..	..	..	351	419
521	..	..	..	316	387
524	..	..	..	300	352
BAR/7	..	..	..	206	304
F21	..	..	..	197	206
Sign. Diff. (P=.05)	..	..	..	82	115
S.E.	..	..	..	±15	±21
Coef. of Var.	..	..	..	25%	24%
Replications	..	..	..	5	5
Planted	..	..	..	7th Dec.	28th Nov.

Average yields of the crosses taken over all seasons show no increase over A637. Nos. 524, 509, 516, 521 and 518 show yields approaching the control. Their parentage is shown below.

524	..	..	..	A640 × C(50)20
521	..	..	..	A640 × A618
516	..	..	..	A640 × UK48
518	..	..	..	A637 × UK48
509	..	..	..	A629 × UK48

Single plant selections made in the F_2 were grown in unreplicated progeny rows but were decimated by jassid attack. 54 selections were made for resistance to this pest and sufficient seed obtained for a replicated trial. Twenty-two of these selections are from A629 × CL20. Selections from AB40 have given the highest average yield.

INTRODUCED VARIETIES

The strain BAR HOP 7 (BAR 7/8.2 × Hopi Acala) and F21 (from BAR 11/9 homozygous for B_2 B_3 B_6) both from the Sudan, have both yielded less than the control and are very susceptible to jassid. 38 selections have been made showing a degree of resistance and will be used for crossing. Strain E54 (from BP 52 × MU8) was introduced from Portuguese East Africa and has shown a high degree of resistance to jassid combined with qualities required in irrigated cotton.

Cotton Agronomy (Makanga)

1. INTERPLANTING OF COTTON AND MAIZE

This was the 3rd successive year recently in which the possibility of planting alternate rows of cotton and maize was investigated at Makanga. The scope of the investigation was expanded to include variations in the within row spacing of maize and cotton. The resultant trial was a 2^5 plaid design with the following factors: Pure stand v alternate rows, early v late planted maize, early v later planted cotton, standard v close spaced maize, standard v close spaced cotton.

The most important findings are given in table IV.

Interplanting reduced the quantity of cotton produced. This effect was particularly severe with late planted cotton or close spaced maize but was less, and statistically insignificant, when the cotton was closely spaced.

Maize yields were substantially increased by interplanting, especially if close spaced. On this year's result, alternate row planting of maize and cotton would not have reduced cotton production, if early planted and close spaced within the row, while production of maize would have increased.

TABLE IV
Interplanting: Total Produce from 1 Acre

Whole area planted with alternate rows of maize and cotton compared with $\frac{1}{2}$ acre of each crop in pure stand.

Method of Planting	Time of planting cotton	Within row spacing in feet		Cotton lb. seed cotton	Maize lb. grain
		Maize	Cotton		
Pure stand	Early	3	2	289	668
	Late	3	2	222	501
Alternate row	Early	3	2	242	1,030
	Early	3	1	279	1,405
	Early	1.5	2	148	1,772
	Late	3	2	111	1,222
L.S.D. 5%				52	402
C. of V.				14.1%	35.6%

2. RIDGING AND MULCHING TRIAL

This trial on a fertile clay loam alluvium at Makanga was planted to cotton in its eighth year. As usual in a year of low rainfall the crop responded with increased yields to boxed ridges, but not ridges alone, in the absence of mulch and to mulch in the absence of boxed ridges: the effects of mulching and boxing were not additive when present together. Details of yields and treatments are given in Table V.

TABLE V
Ridging and Mulch Trial, Makanga
Yield of Seed Cotton in pounds per acre

Cultivation				Flat	Ridged only	Ridged and boxed
No mulch				707	644	1,450
Low mulch				1,621	1,469	1,337
High mulch				1,773	1,601	1,400
L.S.D. 5%				211	Coef. of Var.	30.5%
1%				282	Replications	6
.1%				369		

3. NITROGEN AND POPULATION TRIAL, CHITALA

A 3×6 factorial experiment with three replications was laid out on grey brown sandy loam at Chitala to measure the effects of plant population and nitrogen on a crop of A637 cotton which was regularly blanket sprayed with Sevin and B.H.C. to control pests. Soil data are as follows: pH=6.2; Total N=0.095 per cent.; Available P=5 p.p.m.; K=0.67 m.e. per cent.; B.E.C.=12.5 m.e. per cent.—89 per cent. saturated. The nitrogen as sulphate of ammonia was applied in drills on either side of the ridge on 29/12/60, two weeks after planting.

TABLE VI

Effects of Sulphate of Ammonia and population on Cotton growth and yield

Variety: A637

Yield: lb./acre seed cotton

Treatment	Yield/ acre	Plants/ acre actual 10/5/	Mature height in. 21/4/	Crop analysis %			
				1st Pick		2nd Pick	
				I	II	I	II
Nitrogen							
Nil	960	17,570	48.3	54	5	36	5
200 lb./acre S/A.	1,180***	17,590	58.7	45	8	40	7
400 lb./acre S/A.	1,070*	17,360	66.9	36	9	45	10
L.S.D. 5%	90						
Population							
3 ft. x 24 in. x 3 plants (21,780) ..	1,010	19,150	58.5	50	7	38	5
3 ft. x 24 in. x 1 plant (7,260) ..	1,080	6,490	57.2	34	5	52	9
3 ft. x 12 in. x 1 plant (14,520) ..	1,040	12,380	59.8	38	6	47	9
3 ft. x 8 in. x 1 plant (21,780) ..	1,120	17,320	57.6	52	7	35	6
3 ft. x 6 in. x 1 plant (29,040) ..	1,130	21,480	56.3	43	10	39	8
3 ft. x 4 in. x 1 plant (43,560) ..	1,040	28,300	58.5	54	8	32	6
L.S.D. 5%	125						
Mean	1,070	17,500	58.0	45	7	40	8
Coef. Varn.	12.3%						

Nitrogen at 200 lb./acre S/A, gave a small but statistically significant increase in yield of seed cotton (220 lb./acre). The heavier dressing did not increase yields and tended to make the crop too tall and leggy, to make the crop later and to increase the proportion of Grade II cotton.

4. N, P, K AND SPACING TRIAL, CHITALA

A 2×2×2×3 factorial trial with the NPK interaction confounded to give blocks of 12 plots with two replications was laid out on grey brown sandy loam at Chitala to test the main effects and interactions of fertilizers with spacing. A637 cotton was planted and the experiment was regularly sprayed with Sevin or B.H.C. to control pests. Soil data are as follows:—pH=6.0; Total N=0.086 per cent.; Available P=19 p.p.m.; K=0.71 m.e. per cent.; B.E.C.=13.9 m.e. per cent.—81 per cent. saturated. Superphosphate and sulphate of potash were applied before planting in a band under the ridge. Sulphate of ammonia was top dressed in drills either side of the ridge on 28/12, two weeks after planting.

TABLE VII

Effects of N, P, K and spacing on growth and yield of Cotton

Variety: A637

Yield: lb./acre seed cotton

Treatment				Yield/ acre	Plants/ acre actual 8/5/	Mature height in. 9/4/61	Crop analysis %			
							1st Pick		2nd Pick	
							I	II	I	II
N.	Nil	..	..	1,060	17,510	58.5	38	5	51	6
	200 lb./acre S/A.	..	..	1,180	16,650	65.8	34	5	50	11
P.	Nil	..	..	1,060	16,850	60.0	35	6	51	8
	200 lb./acre supers	..	..	1,180	17,310	62.0	36	4	50	10
K.	Nil	..	..	1,120	16,700	63.2	34	5	52	9
	50 lb./acre K ₂ SO ₄	..	..	1,120	17,460	59.2	38	5	49	8
	L.S.D. 5%	..	..	210						
Spacing 21,700 plants/acre										
	3 ft. x 24 in. x 3 plants	..	..	990	16,130	61.2	30	3	55	12
	3 ft. x 16 in. x 2 plants	..	..	1,060	18,550	62.5	33	6	52	9
	3 ft. x 8 in. x 1 plant	..	..	1,300**	16,560	59.9	42	6	45	7
	L.S.D. %	..	..	150						
	Mean	..	..	1,120	17,080	61.2	36	5	50	9
	Coef. Varn.	..	..	22.5%						

Single plant spacing gave an increase over hills of 3 plants of 410 lb./acre seed cotton, and it gave shorter earlier maturing plants. The main effects of the fertilizers were negligible but the PK interaction was significant and examination of the detailed figures showed a complex of interactions which needs clarification. The best responses appeared to come from P alone, N+P and N+K, but mixtures of P and K tended to depress yields.

5. COTTON SPACING, POPULATION AND THINNING TRIAL, BAKA, KARONGA

A 4x2 factorial experiment with eight replications was laid down on grey brown sandy loam of Karonga series to test four spacing and population treatments in combination with early and late thinning. Four replications were planted on 4th April and four on 30th April, but establishment of the first sowing was bad and these four blocks had to be virtually replanted on 29th April. There was no significant difference between treatments and the Coefficient of Variation was high.

TABLE VIII

Effects of Spacing Population and Thinning Date on Winter grown Cotton

Variety: Not specified

Yields: lb./acre seed cotton

Treatment					Yield	Treatment	Yield
Spacing		Population				Date of thinning	
3 ft. x 1 ft. x 1 plant	13,930	..	..	..	760	Early 12/5/60	755
3 ft. x 2 ft. x 1 plant	7,030	..	..	..	655	Late 3/6/60	760
3 ft. x 2 ft. x 2 plants	13,790	..	..	..	870	L.S.D. 5%	120
3 ft. x 2 ft. x 3 plants	19,010	..	..	..	755		
L.S.D. 5%					170	Mean	760
						Coef. Varn.	29.3%

6. MAIZE/COTTON INTERPLANTING TRIAL, KAFIKISILA, KARONGA

This experiment, designed as a 4×4 Latin square to test the relative merits of pure stand versus intercropping of maize and cotton, was laid down on dimba soil at Kafikisila. Pure stand maize was planted at 3 ft. × 3 ft. × 3 plant spacing on 26/5/60. Pure stand cotton was planted at the same spacing, i.e. rather a low population. The spacing of the interplanted crop is not specified. The maize had to be harvested green to avoid destruction by birds. Under these conditions it was estimated that two acres planted half to pure stand maize and half to pure stand cotton would give 3,455 lb. green maize and 2,640 lb. seed cotton. Two acres of interplanted crops gave 4,180 lb. green maize and 2,980 lb. seed cotton. This is an exceptionally high yield of cotton, and the findings need confirmation.

7. COTTON ROTATION TRIAL, BAKA

A randomized block experiment, with six replications of six treatments designed to test various combinations of summer cropping with a winter cotton crop, was laid down on grey brown sandy loam of Karonga series. All yields were high and there were few differences between treatments.

Treatment					Cotton yield/acre lb.	
(A)	Maize (planted 17/12/59 and harvested 3/5/60) stooked and interplanted with cotton (planted 19/4/59 and harvested 1/11/60)	..	..	..	1,280	
(B)	Maize (planted 17/12/59 and harvested 3/5/60) cultivated between the rows and interplanted with cotton (planted 19/4/59 as above)	..	..	..	1,250	
(C)	Early maturing groundnuts (Early Runner planted 17/12/59 and harvested 11/4/60) followed by cotton (planted 19/4/60 as above)	..	..	..	1,260	
(D)	Late maturing groundnuts (Mwitunde planted 17/12/59 and harvested 27/4/60) interplanted with cotton (19/4/60 as above)	..	..	..	1,020	
(E)	Bare fallow, weeded four times between 5/1/60 and 4/4/60 followed by cotton (planted 19/4/60 as above)	..	..	..	1,210	
(F)	Elephant grass planted January '60 uprooted March '60 burned elsewhere and ash returned to the plots which were then planted to cotton (19/4/60 as above)	..	..	..	1,470	
L.S.D. 5%		..	270	Coef. Varn.	..	18.0%

Extract from Report of the Entomologist

Populations of *Dysdercus* spp. (Cotton Stainer-bugs) were again small this season in all areas in the period from November to April as they have been since 1955. In consequence the insects nowhere reached serious pest status. This was due chiefly to the late rains, little rain falling until late December in most cotton areas. There was also a period of several weeks with no or little rain in the major cotton growing areas in the growing season. In parts of the Lower River no rain fell for a period of 6-7 weeks in February and March, and in most areas in the country rainfall was inadequate or poorly distributed so that growth was poor or uneven.

Deinbollia xanthocarpa (Klotz), which was recorded as a host of *Dysdercus intermedius* last season, has now been shown not to be a true breeding host, although adults and nymphs will feed to some extent on the seeds. *Ostryoderris stuhlmannii* (Taub.) is in the same category—the insects will occasionally suck the seeds but do not breed on this food alone.

The Cotton Jassid (*Empoasca facialis* Jac.), and possibly other species, were more in evidence this season than last, and caused some considerable damage to seedling cotton in some areas of the Lower River and Central Province. This attack, together with the early dry conditions and the later drought, caused a considerable set-back

to many plants, and in a few cases considerable supplying was necessary. However, almost all the plants recovered from this early jassid attack where sufficient moisture was available, and only in very dry areas was the damage serious.

Cut-worms (*Agrotis segetum* (Schiff.)) and *A. ipsilon* (Hufn.) also caused some serious damage to seedling cotton in a few areas, but Harvester Termites (*Hodotermes mossambicus* (Hag.)) in the Lower River were rather less in evidence than usual.

Heliothis armigera (American Bollworm) was of considerable consequence this season, although, as usual, much less in evidence in the Lower River than in other parts of Southern and Central Provinces where serious attacks developed in many areas in March and April, and in a few areas as early as February.

Cosmophila flava F. (Cotton Semi-looper) caused serious defoliation in parts of Central Province, and the attack by this pest was more severe than ever recorded before in Nyasaland. However, only a small percentage of gardens were permanently affected, although in many the plants were retarded and there must have been some loss in yield due to this temporary effect.

Sylepta derogata F. (Cotton Leaf-roller) was also commoner than usual in some areas of Central Province and Fort Johnston District, and caused severe defoliation in a few gardens over a large area within the garden.

Xanthodes graellsii (Feisth.), *Plusia chalcites* Esp. and *Tarache nitidula* F. were generally more numerous than usual this season, but only local damage was done.

A series of illustrated booklets on cotton pests is being published which cover all the known insect pests of cotton in Nyasaland. The first of these ("Insect Pests of Cotton in Nyasaland I. Hemiptera (Bugs).") Bulletin No. 18, Department of Agriculture, pp. 27, 14 figs.) was published in 1961, and two more (Coleoptera and Lepidoptera) are in the press.

COTTON PEST RESEARCH SCHEME

Introduction

The organization of work of the Cotton Pest Research Scheme has followed a similar pattern to that of previous seasons in that the basic investigations into the biology and control of cotton bollworms, together with toxicological studies have continued at the Gatooma Research Station, Southern Rhodesia, while insecticide trials and associated biological studies based on work at Gatooma have been carried out at various centres in the main cotton growing areas of the Federation of Rhodesia and Nyasaland.

The work at the Chitala Experiment Station, Nyasaland, has been increased in scope, and a recording team has been established at Chikwawa in the Lower River district of Nyasaland, with a corresponding reduction in staff at the Makanga Experiment Station. It is considered that Chikwawa offers a more suitable base of operations in the Lower River than Makanga, and for the 1961/62 season it is planned to carry out all work in the Lower River from there. Experimental work has been maintained at the Sabi Valley Experiment Station and, on a more limited scale, work has been continued in Northern Rhodesia in co-operation with the Ministry of African Agriculture.

The present entomological team consists of two Entomologists and a Technical Assistant. It has not been possible to recruit a third entomologist to replace Mr. Sweeney, and there is a vacancy for one Technical Assistant due to the resignation of Mr. Macdonald at the end of the 1959/60 season. Both of these vacancies are for posts in Nyasaland.

General

This season, one of the main projects has been a large-scale extension trial to assess the efficiency of insecticides in controlling cotton insect pests in the main cotton growing areas of the Federation, the results of which are reported. The Scheme is indebted to the advisory staff of the three territories for their help and co-operation in this trial.

In July, 1961, Dr. C. Cottrell began a study of diapause in *Diparopsis* under a Research Fellowship tenable at the University College of Rhodesia and Nyasaland for a period of three years. This work will be carried out in close co-operation with the Cotton Pest Research Scheme.

During the season, it became very apparent that active steps should be taken to bridge the gap between the research worker and the agricultural advisory services in respect of cotton insect control by means of insecticides. To help in achieving this, a course on cotton production was held at the Gatooma Research Station in September, 1961, for agricultural advisory staff from each of the three territories, with the object of providing instruction on cotton growing, with particular emphasis being placed on insect control methods. In addition, an instructional 16 mm. colour film, with commentary, entitled "Insect Pests of Cotton and their Control" has been produced, together with separate sets of coloured slides on cotton spraying and identification of cotton insects.

The following article has been accepted for publication in the September/October, 1961, issue of the *Rhodesia Agricultural Journal*: "Cotton Insect Control Recommendations for 1961/62 in the Federation of Rhodesia and Nyasaland" by J. P. Tunstall and G. A. Matthews.

Climate

Gatooma: The climate for the 1960/61 season was generally very favourable for cotton growing. Total rainfall was 30 inches, and this was well distributed except for a short period of moisture stress at the beginning of December. Warm weather conditions persisted during May, June and into July, which, with sufficient soil moisture, enabled a good top crop to be set in addition to a middle and bottom crop.

The cotton crop was sown on the 15th November on land that had previously received 2 inches of rain. Germination was good, and this was followed by sufficient rain to allow the emergence of the seedling cotton. Picking commenced from the middle of May.

Sabi Valley: The relatively low rainfall of approximately 15 inches evenly distributed throughout the growing season facilitated controlled irrigation of the experimental plots. The cotton was sown on 15th October, but poor germination necessitated re-planting on 26th October. The season was very favourable to plant development and enabled picking to be completed by the end of April.

Chitala: Apart from a few showers no rain fell before the middle of December. During the latter half of December rainfall was well distributed, and it was over this period that the cotton was planted. Good distribution of rainfall was maintained during January and February and into March, and some rain fell during April. Generally, climatic factors were favourable to the growth of the cotton plant.

Chikwawa: Little rain fell before the end of the third week of December, apart from a number of heavy showers in November. During the last week of December heavy rain occurred, and cotton which had been dry-planted earlier came away well in most cases, although there were instances of poor germination necessitating more

than one supplying. Rainfall was generally sufficient during January. A dry period occurred in March, which was followed by late showers. Generally, the total rainfall was less than adequate in most areas, and with uneven distribution growth of the cotton plant suffered.

Biological Investigations

A. BEHAVIOUR STUDIES OF *HELIOTHIS ARMIGERA* AND *EARIAS BIPLAGA*

Behaviour studies of *Heliothis armigera* and *Earias biplaga* under natural conditions have been carried out at Gatooma, the technique being similar to that used previously for *Diparopsis castanea* (Hmps).

(i) THE BEHAVIOUR AND NATURAL MORTALITY OF *HELIOTHIS* UNDER FIELD CONDITIONS

Continuous observations were made on the behaviour and natural mortality of *Heliothis* from egg hatch to emergence from the soil as an adult moth. Ten eggs, which had been laid under natural conditions during the first half of March were marked and observed. The eggs, which were of unknown age, hatched throughout the 24 hour period, with no indication of a definite time of hatching as is the case with *Diparopsis*. The mean length of the larval period was 26 days (range 19–28 days), while that for the pupal period was 21 days (range 18–25 days). The former period was based on eight subjects, while the latter was for four subjects only. The figures suggested that the mean length of life cycle for egg hatch to moth emergence was 6–7 weeks.

The exposure of the larvae during transfer from one fruiting point to another, during pupation and at other times was measured. It was found that all major movements, namely for transfers and for pupations, did not take place over any definite period, but occurred throughout the 24 hour period, although there was some tendency for transfer movements to be more numerous during the day than at night.

Larval transfer movement was most commonly made from the eleventh 24 hour period following egg hatch, although nearly all the larvae made at least one transfer before this period. The total number of transfers made by the larvae varied considerably from 4 to 15, with a mean of 9 transfers. No preference was shown for either buds or bolls.

Moth emergence occurred throughout the 24 hour period, but numbers were too low to show whether there was any tendency for moths to emerge at any particular time.

Mortality was low, one larva being killed by *Agonoscelis* sp.

There is a marked difference in behaviour between *Heliothis* and *Diparopsis*. In contrast to the relatively few transfer movements of *Diparopsis* which invariably occurred during the hours of darkness, *Heliothis* attacked a large number of buds and bolls and all movements over the plant occurred at any time over the 24 hour period.

(ii) THE BEHAVIOUR AND NATURAL MORTALITY OF *EARIAS* UNDER FIELD CONDITIONS

Observations on the behaviour and natural mortality of *Earias* commenced from the middle of April when ten eggs, which had been laid and incubated under insectary conditions, were placed before hatching on leaves and bracts of buds and bolls.

No figures for the incubation period under field conditions are available. All the eggs hatched between 0800 and 1500 hours. The mean larval period was 23 days (range 21–25 days) and the mean pupal period was 20 days (range 18–21 days). These figures which are based on nine and three subjects respectively, suggest a length of life cycle from egg hatch to moth emergence of some six weeks.

An average of ten transfer movements per larva was made (range 7-14), virtually all of which occurred during the hours of daylight. Transfers were made throughout the larval period with no very marked period of movement. Pupations occurred from 0300 hours to 1300 hours the majority occurring between 0700 and 1000 hours. In each case the larvae pupated under leaves and other debris on the ground. Apart from one larva which died from unknown causes, all larvae successfully completed the larval cycle.

In contrast to *Heliothis*, *Earias* tended to show definite periods over which major movements occurred. In this respect it is somewhat similar to *Diparopsis* but, unlike this insect, the movement tended to be confined to the hours of daylight instead of at night.

Both *Earias* and *Heliothis* attacked and damaged a far greater number of buds and bolls than *Diparopsis*, and in consequence movement from one fruiting point to another was much more frequent.

B. THE FORMATION OF DIPAROPSIS OVERWINTERING PUPAE AND THE PERIOD OF SUBSEQUENT MOTH EMERGENCE

Experiments to determine the proportion of larvae forming overwintering pupae as the season advanced, and the period of subsequent moth emergence were carried out at the Gatooma, Chitala, Makanga, and Sabi Valley Experiment Stations. The method used was to make collections of 5th instar larvae contained within bolls at weekly intervals, and to allow them to pupate in cages set in a pupation garden. The emerging moths were recorded daily. At Gatooma and Chitala the period of moth emergence from overwintering pupae was also determined by setting down field emergence cages on the previous season's cotton land which had been left fallow. It is considered that this latter method, in which the emergence is recorded from a pupal population naturally produced in the field, gives a more reliable assessment of the "carry over" moth flight as it is never possible to simulate field conditions entirely under pupation garden conditions.

At Gatooma, it was shown that the proportion of larvae forming overwintering pupae increased as the season advanced confirming results of previous seasons. By the middle of March some 5 per cent. of the larvae were producing overwintering pupae, and this steadily increased, reaching 100 per cent. towards the end of April. From this latter date until the beginning of July when collections of 5th instar larvae ceased, no short-term pupae were produced. The subsequent emergence of moths from overwintering pupae, under pupation garden conditions, extended from the middle of August until the end of February, with maximum emergence occurring from the end of November until the middle of January. A small proportion of the pupae (0.6 per cent.) were still alive at the end of the season.

The period of moth emergence, as determined from the field emergence cages, extended from September until April, with maximum emergence occurring from the beginning of December to the end of February. Compared with the pupation garden experiments, the emergence was somewhat extended, confirming previous seasons' results. Four per cent. of the pupae remained alive in the soil at the end of the season.

With both experimental methods, the emergence of moths from overwintering pupae did not show any pronounced peak of emergence over a short period. Instead, the emergence tended to remain uniformly high over the period of maximum emergence.

At Chitala, under pupation garden conditions, 5th instar larvae collections were made during April, May and June, and for each of these months the proportion of larvae forming overwintering pupae was 69 per cent., 77 per cent. and 94 per cent.

respectively. The subsequent period of moth emergence from these overwintering pupae extended from mid-August until towards the end of April, with the period of main emergence from mid-February until the end of March. There was a pronounced peak of emergence during March. During August there were indications of a slight increase in the rate of moth emergence. No emergence occurred from the second week of September until the third week of January. At the end of season 0.4 per cent. of the pupae remained alive.

The field emergence cages set on naturally infested land gave essentially a similar pattern of moth emergence from overwintering pupae.

At Makanga, collections of 5th instar larvae were also made during April, May and June, and for each of these months the proportion of larvae forming overwintering pupae was 59 per cent., 70 per cent. and 60 per cent. respectively. The period of subsequent moth emergence from these pupae extended from August until the middle of March, with a distinct peak of emergence during January. Little emergence occurred outside this month. There were no pupae remaining alive at the end of the season.

At the Sabi Valley Experiment Station, 5th instar larvae were collected from February to May inclusive. Until the middle of April, the proportion of larvae forming overwintering pupae remained between 0-13 per cent., when there was a sharp increase to between 50-71 per cent. during the remaining period. Pupal mortality, however, was heavy in the cages, and this was reflected in the low emergence of moths from overwintering pupae. The results showed that the emergence period extended from July until April, but the emergence was too low to indicate any peak emergence periods.

In contrast to Gatooma, the emergence pattern of moths from overwintering pupae at both Chitala and Makanga showed a distinct peak of emergence over a relatively short period, but whereas this occurred during January at Makanga, it was delayed until March at Chitala.

C. THE EFFECT OF PUPAL DEPTH ON MOTH EMERGENCE FROM OVERWINTERING PUPAE

The effect of pupal depth on moth emergence from overwintering pupae was investigated at the Gatooma, Chitala, Makanga and Sabi Valley Experiment Stations.

At Gatooma, where pupae collected from the field at intervals from July until September were artificially buried at depths of $\frac{1}{2}$ inch, 2 inches, 4 inches, 6 inches and 8 inches, the subsequent emergence pattern confirmed the results of previous seasons' work in that the main period of emergence is advanced at the deeper depths and retarded at the shallower depths.

At Makanga, where pupae collected over the period April to July were buried at depths of $\frac{1}{2}$ inch, 1 inch, 2 inches, 3 inches, 4 inches, 6 inches and 8 inches, no marked differences in emergence periods were evident, the emergence pattern conforming to that obtained from naturally formed pupae.

The experiments at Chitala and Sabi gave inconclusive results due to heavy pupal mortality.

D. THE EFFECT OF TEMPERATURE ON MOTH EMERGENCE FROM OVERWINTERING PUPAE

Overwintering pupae collected in July, September, October and November at Gatooma were subjected to continuous temperatures of 65°F, 70°F, 75°F and 85°F. Humidity was not specifically controlled and relative humidity ranged from 60-75 per cent.

At 65°F pupal development was largely suppressed, there being only a very slow drawn-out emergence, with 60-75 per cent. of the pupae still alive in September in the following year. At 70°F, 10-20 per cent. of the pupae had not emerged by that date, while at 75°F, all pupae gave rise to moths within the 5th to 18th week following the date of incubation. At 85°F, the emergence pattern was similar to that at 75°F, except that some 4-14 per cent. of the pupae had not given rise to moths by September of the following year.

The October and November collections tended to show an earlier emergence than those of July and September, which was primarily due to the fact that with the former some of the pupae had commenced development at the time of collection.

These experiments indicated that maximum pupal development occurred at 75°F, while at the lower and higher temperatures development was retarded or suppressed to a greater or lesser degree.

E. THE EFFECT OF MULCHING ON MOTH EMERGENCE FROM OVERWINTERING PUPAE

Overwintering pupae were collected from the field during September and October at Gatooma, and buried in pupation cages sited under grass mulches of 9 inches, 6 inches and 3 inches in thickness, and in bare soil. For each mulch and the bare soil treatment, separate batches of pupae were buried at depths of 1½ inches and 3 inches.

Results showed that suppression of pupal development occurred, the degree of which depended upon the thickness of the mulch. The proportion of pupae remaining alive by the following May for the 9 inches, 6 inches and 3 inches mulch and for the bare soil was 65 per cent., 51 per cent., 29 per cent. and 4 per cent. respectively. There were no observable differences in emergence between the two depths at which pupae were set.

Under the mulch, the soil remained very wet throughout the season, the degree of wetness being greater with increase in thickness of the mulch, and it is considered that this was a major factor causing suppression of pupal development.

F. BEHAVIOUR RESPONSE OF DIPAROPSIS LARVAE TO COTTON VARIETAL DIFFERENCES

Preliminary investigations into the behaviour response of *Diparopsis* larvae to cotton varietal differences were begun, and these indicated that the period of wandering of 1st instar larvae from egg hatch to penetration of a fruiting point was more prolonged on hairy varieties than on glabrous varieties. This work is to be intensified during the 1961/62 season, and the behaviour of both *Diparopsis* and *Heliothis* is to be compared on various hairy and glabrous varieties. This will include oviposition studies.

G. REARING OF COTTON INSECTS FOR LABORATORY WORK

Cultures of *Diparopsis*, *Heliothis*, *Earias*, *Dysdercus* spp. and *Phonoctonus nigrofasciatus* have been maintained during the season at Gatooma at a sufficiently high level to provide materials for toxicological work, and small-scale behaviour experiments.

Chemical Control of *Diparopsis* and Other Insect Pests of Cotton

A. BIOASSAY TESTS

(a) LABORATORY TOXICITY TESTS

(i) *Diparopsis* eggs

The method of dipping *Diparopsis* eggs into various concentrations of insecticides, provisionally reported in the Annual Report for 1958/59, has been continued.

Many commercially available insecticides have now been tested together with a number of experimental insecticides. Only one new insecticide—Code No.: NC930—a carbamate, has been shown to be as toxic to *Diparopsis* as Sevin. Unfortunately this compound is phytotoxic to cotton. The concentration to give 50 per cent. mortality for various insecticides has been determined as follows:

Chlorinated hydrocarbon insecticides

Telodrin (WL1650)	..	..	..	..	0.011 per cent.
Thiodan	..	..	..	..	0.015 "
B. H. C.	..	..	..	..	0.015 "
endrin	..	..	..	..	0.018 "
aldrin	..	..	..	..	0.032 "
dieldrin	..	..	..	..	0.053 "
DDT	..	..	..	..	0.179 "
chlordan	..	..	..	..	0.75 "
toxaphene	..	..	..	..	4.06 "

Organophosphorus insecticides

methyl parathion	..	..	..	..	0.0003 per cent.
parathion	..	..	..	..	0.0016 "
Lebaycid	..	..	..	..	0.02 "
Malathion	..	..	..	..	0.15 "
Rogor (new formulation)	..	..	..	..	0.30 "
Diazinon	..	..	..	..	0.32 "

Carbamate insecticides

NC930	..	..	..	..	0.0005 per cent. (provisional formulation)
Sevin 85 per cent. sprayable	..	..	..	..	0.0005 per cent.
Sevin 50 per cent. wettable	..	..	..	..	0.004 "

The difference in toxicity between the two Sevin formulations is probably due to a difference in particle size, the sprayable powder being air-milled and having much finer particles.

(ii) *Heliothis*—3 day old larvae

By "painting" young larvae with various concentrations of insecticides and then allowing them to feed on a fresh *Dolichos* flower for twenty-four hours, the following LC50's have been obtained:

Endrin(emulsifiable concentrate formulation)	..	..	..	0.00245 per cent.
DDT	"	"	"	0.00428 "
Thiodan	"	"	"	0.0176 "
Sevin (dispersible paste formulation)	..	..	..	0.047 "

(iii) *Dysdercus* adults

Adult stainers were caged for twenty-four hours on single leaves sprayed with Sevin, DDT and Thiodan respectively. The mean percentage mortality from two tests was as follows:

Insect	Insecticide	Concentration				Control
		1%	0.1%	0.01%	0.001%	
<i>Dysdercus intermedius</i>	Sevin	100%	95%	65%	0%	5%
	DDT	55%	63%	6%	0%	0%
	Thiodan	89%	35%	0%	6%	9%
<i>D. fasciatus</i>	Sevin	100%	95%	55%	0%	0%

In addition to being very toxic to stainers Sevin appears to effect a very rapid kill, thus at 1 per cent., in the above tests, 100 per cent. mortality was achieved within two hours.

(iv) *Phonoctonus nigrofasciatus*

Tests with the predator are complicated by the predator being cannibalistic if hungry and no stainers or other food is available. However, tests indicated that Sevin at 0.1 per cent. is very toxic to *Phonoctonus*, but that it is not so rapid in its effect compared with *Dysdercus*. Further tests are necessary to determine to what extent *Phonoctonus* is affected under field conditions.

(b) WANDERING OF 1ST INSTAR LARVAE (DIPAROPSIS)

Further tests have been carried out using "continuous observation bioassay", to study the behaviour and period of wandering of 1st instar *Diparopsis* larvae from the time of egg hatching to death or penetration of a bud or boll.

These tests have been directed mainly at assessing the persistence of Sevin spray deposits under various conditions. In each case the sprays were applied as under field conditions to single potted plants, using a tail-boom sprayer.

(i) *Persistence under laboratory conditions*

The initial mean wandering period on young plants sprayed with 0.5 per cent. Sevin (85S) at the rate of 10 gallons per acre was 22.8 minutes (range 8-44) the eggs being placed on the upper surface of leaves. The mean wandering period did not change significantly over the first ten days and had only increased by a factor of 2 over a period of 35 days, to 44.3 minutes range (17-60). The mean wandering period on unsprayed plants did not change significantly over this period, being over 94 minutes on each sampling date.

(ii) *Persistence in sunlight, but no rain*

When the plants were kept out of doors in direct sunlight but transferred to laboratory conditions whenever there was rain, and during the night, the initial wandering period of 22.9 minutes (range 12-32) did not increase significantly during the first six days. The number of hours of sunlight increased to over eleven per day on the 6th, 7th and 8th days, during which period there was a significant increase in the mean wandering time to 37.9 minutes (range 21-83). There was little intense sunlight over the rest of the test period corresponding to (i) above. The mean wandering period increased to approximately 50 minutes after 30 days.

(iii) *Persistence under rainfall conditions*

The effectiveness of Sevin is reduced considerably by rain, the extent and rate of the loss depending on the amount and intensity of the rain and the size of the plant. Small more open plants are more subject to rainwash than larger plants where the upper leaves protect the inner framework of the plant. Initial tests indicate that the degree of hairiness of the plant influences spray retention, but this and also the effect of dew on the plant need further study.

To assess the loss of persistence due to rain, artificial rain was provided by "Rain Jet" nozzles working at tap pressure and directed so that the rain fell on to the plants from a height of over 12 feet by gravity, and at an angle of about 80°. Various formulations of Sevin have been tested, together with Sevin plus "Lovo" spray formulants (based on amine stearate).

An assessment of the wandering period of larvae before rain and after the application of one inch of rain (rate approximately four inches per hour) indicated that "Lovo" 190 added at 2.0 per cent. to technical Sevin applied at 0.5 per cent. a.i. increased persistence compared with Sevin 85 per cent. sprayable also used at 0.5 per cent. a.i. The initial wandering period was, however, increased by the addition of "Lovo". An experimental "Lovo" formulation CR 5000/1 also increased the initial wandering period. "Lovo" 179 was slightly phytotoxic.

Using "Lovo" 190 at lower concentrations (1.0 per cent. and 0.5 per cent.) increased persistence was not so marked and there was also no indication that a lower concentration of Sevin could be used without considerably increasing the wandering period.

Leaves from some of the plants used in the above tests were taken to assess the degree of persistence with *Dysdercus intermedius* as a test insect.

Mortality of adult stainers caged on leaves for 24 hours				Percentage mortality	
				No rain	After 1 inch rain
Sevin 0.5% (85S)	..	..	..	100	0
Sevin 0.5% + Lovo 190 2%	..	..	..	91.7	58.3

Although Lovo definitely increases the persistence of Sevin, the cost of the Lovo formulations precludes their use except in very low volume application (up to 4 gallons per acre). Tests with other adjuvants designed to increase persistence to rainfall are being planned.

(iv) Persistence in relation to plant growth

Assessments were made of the wandering period of *Diparopsis* 1st instar larvae on young cotton plants, one, eight and fourteen days after spraying. Over the fourteen day period in which the leaf area of these plants increased nearly three times, there was a significant increase in the wandering period and the number of larvae (eggs placed on leaves) successfully penetrating increased from 0 per cent. to 75 per cent. In a similar experiment on more mature plants, the number of larvae (eggs placed on bracts) successfully penetrating increased from 20 per cent. to 50 per cent.

Thus, the increase in plant growth especially in the early part of the season is sufficient to necessitate spraying at least at seven day intervals irrespective of other factors determining persistence.

(c) WANDERING OF 1ST INSTAR LARVAE (HELIOTHIS)

Using "continuous observation bioassay" the behaviour and period of wandering of *Heliothis* larvae has been observed on plants sprayed to "run off". Most of the larvae fed on the egg shell before leaving the piece of paper on which the egg had been laid. Whereas *Diparopsis* larvae tend to keep wandering until they find a bud or boll, *Heliothis* larvae frequently stop for lengthy periods, and it is more difficult to obtain comparable figures. There are, however, indications that Sevin and Thiodan are at least as effective as DDT under these conditions. When the plants were sprayed with a tailboom and subjected to one inch of rain, the Thiodan (EC) and DDT (EC) were more persistent than Sevin (85S).

(d) TOXICITY TO DIPAROPSIS LARVAE ALREADY INFESTING BUDS AND BOLLS

When plants were sprayed to "run off", Sevin at 1.0 per cent. and 0.1 per cent. gave some control of larvae which had been allowed to infest buds one day before spraying, the buds being examined one day after spraying. DDT at 1 per cent. gave no control and endrin at 0.25 per cent. gave similar control to Sevin at 1 per cent.

Rogor gave poor control at one per cent. When sprayed with a tailboom at field application rates Sevin does not show any effect on larvae inside buds and bolls at the time of spraying. A few young larvae are killed when exhibiting "re-entry" movements within the bracts. Thioclor showed a similar effect to Sevin.

(c) RELATIVE TOXICITY TO DIFFERENT LARVAL INSTARS OF DIPAROPSIS

To determine any difference in toxicity to different larval instars of *Diparopsis* dewaxed "drinking straws" were treated with Sevin. The straws provided a fairly uniform surface similar to a glabrous cotton stem, on which the 1st instar larvae readily walk in the early hours of the morning, following egg hatching. Unfortunately there has been no success with 3rd and 5th instar larvae although the tests have been carried out at night when the larvae normally make "re-entry" movements in the field.

The 1st instar larvae were allowed to walk for known lengths of time on the straws before being placed on a clean bud for twenty four hours. 50 per cent of the larvae wandering for approximately seven minutes on straws dipped in 0.01 per cent Sevin died within twenty-four hours.

B. SPRAY COVERAGE ASSESSMENTS

Following the development of the tailboom for knapsack sprayers, field on spray coverage this season were conducted to determine whether the coverage of bell done cotton obtained with the tailboom could be improved.

Instead of using table tennis balls as spray targets small discs of photographic film 9/10th inch diameter, pinned to the three bracts of bud and bolls were used. A Croceine scarlet spray solution was employed and the three discs from each bud or boll were washed together in Lissapol solution and the deposits measured colorimetrically.

Comparing the standard six Y4 "Cone Jet" nozzles with eight Y3 "Cone Jet" nozzles the mean deposit was slightly higher with less variation when standard nozzles were used. When the Y4 nozzles were compared with 117.6 hollow cone nozzles with No. 13 cores and 650050 fanjet nozzles, the Y4 nozzles gave better coverage than either of the other two types of nozzle. This was probably due to the spray droplets from a Conejet nozzle approaching the cotton from more angles than would be the case with the other types of nozzle, and thus penetrating between leaves more readily.

Light aluminium guards placed in front of each nozzle to prevent leaves touching the nozzle orifice were not very successful, and caused more plant damage in dense cotton than any increase in spray coverage warranted.

C. FIELD INSECTICIDE TRIALS

(1) TIMING OF APPLICATION TRIAL

This trial was carried out at a number of centres in the Federation, as shown in Table I, to determine the period over which applications of insecticide should be made, and the optimum interval between successive applications. Sevin was applied at 0.5 per cent. a.i. in 10-20 gallons of spray per acre depending on plant growth. Intervals between applications are shown in Table I together with the yield in pounds of seed cotton per acre and percentage damaged seed cotton. DDT at the same concentration was applied at Gatooma and Chitala to the "blanket" treatment to control *Heliothis*.

The "blanket" treatment involved spraying at least weekly (additional sprays were applied following heavy rain) from first buds until reaping had commenced and this treatment was used as the control at all centres. An unsprayed control was omitted at Gatooma, but unsprayed cotton adjacent to the trial yielded less than 100 pounds of seed cotton per acre. As rainfall considerably reduces the effectiveness of Sevin, the feasibility of applying sprays according to rainfall records was investigated at Gatooma. This treatment, sprayed at fortnightly intervals, unless $\frac{1}{2}$ inch of rain fell in the interval, received eleven applications and gave a significantly higher yield than twelve weekly applications.

All sprays were applied with a knapsack sprayer fitted with a tailboom. The dust treatment at the Gambia Allot was applied by means of a Kestrel duster or "bag of dust". This was a 5 per cent. Sevin dust applied at 15-20 pounds per acre.

Entomological records were taken regularly on all the trials, and indicated that *Heliothis* was of considerable importance. No red bollworm was recorded at Mount Makulu, Northern Rhodesia.

A summary of bollworm egg and larval counts is given in Table II. The most significant results of the trials were the lack of control of *H. b. 1st* by Sevin under rainy conditions and the effect of rainfall on the timing of spray applications. As Sevin would appear to give good control of *Heliothis* on single plant bioassays, it is probable that the lack of control noted in the above trials is correlated with persistence.

These results, considered in relation to the laboratory data, indicate that weekly sprays are essential, especially during the early part of the season, and that sprays should be repeated whenever rain falls. Later sprays may be spaced at fortnightly intervals if dry conditions prevail. The trials have also shown that it is not wise to recommend a fixed spray period of eight to ten weeks, if a bollworm infestation is still present. Thus in the 1961-62 spraying recommendations (Tunstall and Matthews, 1961) farmers are advised to "count" the crop and apply extra sprays depending on the actual status of the bollworms and the crop potential.

(2) RELATIVE EFFECTIVENESS OF SEVIN, DDT AND THIODAN SPRAYS AND SEVIN DUST

This trial was carried out at Gatooma, to determine whether Sevin dusts were as good as sprays and whether Sevin, either alone or in combination with DDT; DDT; and Thiodan, would give satisfactory control of all the main insect pests. See Table III.

All treatments received ten applications at weekly intervals. In contrast to the previous season, there was heavier rainfall in January, February and this resulted in complete lack of control of the bollworms by the dust formulation. As *Heliothis* was the major pest Thiodan and DDT outyielded the Sevin treatments in contrast to the 1959/60 season in which *Diparopsis* was the major pest. DDT mixed with Sevin, both formulated as wettable powders, gave better control of *Heliothis* than Sevin alone. However, the reduced concentration of Sevin resulted in an aphid build-up. Thiodan controlled the aphids, but on the DDT plots it was necessary to spray Rogor to control aphids. This trial confirmed that Sevin is the most suitable insecticide for *Diparopsis* control and that DDT and Thiodan are better for *Heliothis* control.

(3) RED SPIDER MITE SPRAY TRIAL

Outbreaks of red spider mite (*Tetranychus* spp.) have occurred in the Sabi Valley and to a lesser extent at Gatooma towards the end of the season. To determine the effect of spider mite attack on yield a trial was laid out at Sabi Valley Experiment Station. Treatments were confined to an eight weekly spray period following 1st buds

(see Table IV). Unfortunately, *Heliothis* was the major pest and as Sevin was used for bollworm control, the yield results do not reflect the true effect of red spider mite. A Sevin+DDT treatment (cf. treatment 3 of above trial) was also included to determine whether Sevin+DDT would satisfactorily control *Heliothis* under irrigated conditions.

Tedion controlled the red spider mite, but gave no control of aphids, whereas Rogor gave good control of both pests during spraying. There was little residual effect, and populations built up considerably during the month following cessation of spraying. An insecticide/acaricide to control both red spider mite and aphids is thus to be preferred to a specific aphicide or acaricide.

The addition of DDT to Sevin did result in an increased yield, but *Heliothis* populations were still high and better control could undoubtedly have been obtained by changing solely to DDT over the main *Heliothis* attack.

D. EXTENSION TRIAL

A large-scale extension trial was carried out throughout the Federation to assess the efficiency of insecticides in controlling cotton insect pests, to determine differences in response between the main cotton producing areas, and to determine whether seed cotton and lint quality characters were affected by controlling pests with insecticide.

The following report briefly summarizes the trial, the results of which will be published separately.

The trial consisted of a series of plots, each plot divided into two halves or sub-plots. One sub-plot was treated with insecticide while the other was left untreated. Certain plots were sited on land owned by Master Farmers and ordinary growers, while others on Government-owned land served as control plots.

A sampling area was demarcated on each sub-plot for recording plant growth and insect populations during the season. Yield data was taken not only from the sampling area, but also, on most plots, from the whole sub-plot to determine the extent "edge" effects and various hazards such as termite mounds within the fields affected yields.

All plots were sown to variety Albar 637. In Nyasaland, row spacing was three feet, with plant holes, thinned to three plants each, spaced at two foot intervals along the row. Elsewhere, single plants at nine inch spacing were grown in rows three feet or three feet six inches apart.

In Nyasaland, a soil analysis was carried out at the beginning of the season, indicating that phosphate and potash levels were satisfactory, and that the nitrogen status varied from low to medium. Fertilizer was applied mainly as sulphate of ammonia to some of the plots.

All plot holders were instructed to ensure that cultivations, particularly weeding and thinning were carried out at the correct time. Supplying was necessary on most plots, as a result of poor initial germination. With climatic conditions generally favourable for cotton plant development, the cotton on many plots had a high potential.

All plots received a minimum of eight weekly sprays of Sevin used at 0.5 per cent. a.i. in 10-20 gallons per acre depending on plant growth, and applied with a knapsack sprayer fitted with a tailboom. Additional Sevin sprays were applied to some plots, and a few plots received applications of DDT for *Heliothis* control and Rogor for red spider mite control. A number of difficulties such as tree stumps and uneven rows contributed towards some uneven spray application by the spray operators. After a few initial set-backs, most plots received an average of 16-20 gallons per acre per application, slightly higher than originally planned.

Records of plant growth and insect populations were taken regularly throughout the growing period by recording teams in each of the main areas. The first major pest was jassid (*Empoasca fascialis*) which was widespread throughout the trial, causing, on certain plots, severe damage from which the unsprayed plants never fully recovered. The main red bollworm attack on plots in the Southern Province, Nyasaland, was early in the season, January/February, whereas in the Central Province the attack was mainly in March. In Southern Rhodesia, red bollworm was present over most of the season, although during the severe *Heliothis* attack, numbers declined and few red bollworm larvae could be found. Red bollworm was not recorded on the single Northern Rhodesian plot. *Heliothis* was undoubtedly a major pest in the 1960/61 season, occurring to some extent on all plots. The season was also characterized by the severe outbreak of leaf eaters, notably *Cosmophila flava* and *Sylepta derogata* which caused severe leaf damage on unsprayed plots in the Central Province, Nyasaland, and at Gatooma.

The yield data (Table V) showed an overall average increase of 655 pounds of seed cotton per acre from 40 plots. In most cases, low yield increases can be attributed to agronomic factors such as late sowing, thinning and poor weeding and other cultivations. The only negative results, on an irrigated plot, was partly agronomic and partly due to lack of *Heliothis* control at a crucial stage.

The trial is to be repeated next season to assess improvements in technique, and seasonal variation.

E. DEVELOPMENT OF SPRAYING EQUIPMENT

The "tailboom" modification for knapsack sprayers described in last season's Report has been improved, and is now produced commercially on a limited scale.

Thirty-five units were used in the Extension Trial and, apart from a few minor faults which the sprayers developed, the improved tailboom functioned perfectly.

Whereas the knapsack sprayer is the most economical machine for relatively small acreages of cotton, there is a definite need for a small tractor-mounted unit for medium range acreages. In view of this, a special spray boom on which "tailbooms" can be easily fitted has been designed to fit a low volume tractor-mounted sprayer. To allow for the low clearance of small tractors, the boom is to be tested during 1961/62 on cotton planted in strips seven rows wide with tractor paths nine feet wide between strips. A secondary crop, e.g. groundnuts, will be grown along the tractor paths.

The type of tractor-mounted boom described could be used equally effectively on high clearance tractor sprayers.

Cultural Control of *Diparopsis*

It has been shown that the time of *Diparopsis* moth emergence is affected by pupal depth and during the 1959/60 season, it was demonstrated that if overwintering pupae were buried between 4-8 inches, 84 per cent. of the total moth emergence took place by the end of December, whereas only 36 per cent. of the emergence occurred by this date if pupae were buried between 0-4 inches. To assess whether this shift in the time of moth emergence could be obtained under field conditions, a full-scale field trial was laid out at Gatooma on land sown to cotton in 1959/60 season, and which was known to be heavily infested with *Diparopsis* pupae. Land treatments were as follows:

- (a) Left fallow, following destruction of old cotton plants.
- (b) Ploughed, hand cultivated, and then sown to maize.
- (c) Double trenched by hand so that the top 4 inches of soil in which the majority of pupae are normally found, was inverted with the 4-8 inch level, and then sown to maize.

The ploughing and double trenching was completed by August, 1960.

The effect of the land treatment on moth emergence was assessed by recording the number of moths emerging daily by means of field cages, covering a total of 0.09 acre for each treatment.

The results did not show that the double trenching had effected an appreciably earlier moth emergence, although during November there were indications of a greater emergence from this treatment than from the other treatments, but this was not maintained. With all treatments the emergence period extended from September to April, with maximum emergence during December, January and February. There were, however, considerable differences in the total moth emergence between treatments, 630, 328 and 209 moths being recorded for treatments (a), (b) and (c) respectively. The lower number of moths emerging from the double trenched land may have been due to moths failing to reach the soil surface. This also may have masked any shift of emergence of which there was an indication in November, especially as failure to penetrate the soil may be increased as the soil becomes more and more compacted by rain as the season advances. Normal maize cultivations may have produced an intermediary effect. Pupal sampling did not indicate that there was any appreciable mortality of pupae through mechanical destruction.

Agronomy Experiments

Spraying cotton with insecticides will only be economic if there is a high potential yield. As previous agronomy work on cotton in Nyasaland has been carried out under unsprayed conditions, it is necessary to reassess spacing, fertilizer and other agronomic practices for sprayed cotton. Two trials to investigate these factors under sprayed conditions were carried out at the Chitlada Experiment Station in collaboration with the Agronomist, Chitedze Research Station. Details and results of the two trials are given in the report for the Chitedze Research Station.

Other Work

Observations on alternate hosts of cotton insect pests continued at Chitala and in the Sabi Valley. A check was kept on the incidence of pink bollworm (*Pectinophora gossypiella*). Following the cutting out of the host plant *Hibiscus dongolensis* near cotton lands, pink bollworm only occurred in very low numbers. It was found on *H. dongolensis* at Nyanyadzi, some miles north of the infested area of 1959.

The winter cotton at Karonga, Nyasaland, was visited, and proposals for limited observations on insect pests in the area, especially following the change of sowing date, have been made.

Discussion

While investigations into other methods of control have continued, the field and extension trials carried out during the 1960-61 season have clearly demonstrated that the main cotton insect pests can be controlled in all the cotton growing areas in the Federation by using insecticides. Although this method is the most promising and economic method of control available its success depends on correct application and timing of the appropriate insecticide for the various pests. It is unfortunate that there is not one insecticide which can be used throughout the spray period. Sevin has been shown to be most suitable for *Diparopsis* and *Dysdercus* control, whereas DDT is required for *Heliothis* control. It has been shown that, in the 1960-61 season at least, the main *Diparopsis* moth emergence was different in the main areas—the Lake Shore and the Lower River districts of Nyasaland and at Gatooma in Southern Rhodesia. Thus, the timing of sprays will vary considerably from area to area and even within one locality. Mites have tended to increase in importance with the present spray programme for bollworms, and this pest must also be considered in future work.

As much of the cotton in the Federation is grown on small acreages the problem of spray application is a very real one. This has been successfully overcome by the development of the "tailboom", principally for modifying knapsack sprayers so that adequate spray coverage over the whole plant can be maintained throughout the growing period. The tailboom system of spraying is now being investigated with tractor-mounted equipment.

To obtain the full benefit of crop protection it is essential that the cotton crop should have a high potential yield. As all previous agronomic work has been with different varieties and subject to uncontrolled insect attack, there is need to re-investigate responses to fertilizer and plant population with the new variety Albar 637 and other strains under sprayed conditions. The effect of certain plant characteristics, such as hairiness, on the behaviour and natural mortality of the bollworms, and their effect on spray retention and rate of uptake of insecticides by bollworms and stinkbugs must also be studied. A start on such work has been made, but further work with close collaboration between agronomists, entomologists and plant breeders is essential.

Summary

Climatically the 1960-61 season was generally favourable for cotton in the Central Province (Chitala) of Nyasaland and in Southern Rhodesia (Gatooma and Sabi Valley). In the Lower River (Chikwawa), rainfall was less than adequate in most areas for optimum plant growth.

Continuous observations on the behaviour and natural mortality of *Heliothis* and *Leptinotarsa* were made from egg hatch to emergence from the soil as adult moths.

Studies on the production of *Diparopsis* overwintering pupae and the period of subsequent moth emergence were carried out at various centres in the Federation. Whereas at Gatooma moth emergence extended from September to April with maximum emergence from the December to February, in Nyasaland the overall period was similar but with a definite peak of emergence in February, March at Chitala, and during January at Makanga. Other pupation work concerned pupal depth, effect of temperature, and mulching.

Preliminary observations on the response of *Diparopsis* to different cotton varieties were made.

Double trenching was unsuccessfully used as a method of shifting the period of *Diparopsis* moth emergence at Gatooma.

Progress was made in the study of the persistence of insecticide deposits especially Sevin, on the cotton plant in relation to climatic conditions and plant growth.

The timing of spray applications was studied on a field scale at various centres in the Federation, and indicated that weekly sprays are essential, especially during the early part of the season. Thiodan has been shown to be a promising insecticide for cotton insect control.

A large-scale extension trial was carried out throughout the Federation, in which an average yield increase of 655 pounds of seed cotton per acre was obtained by spraying with knapsack sprayers fitted with a tailboom. This trial indicated that given a high potential yield, spraying can increase cotton yields considerably, and that agronomic factors need further investigations to determine optimum conditions for sprayed cotton.

To bridge the gap between the research worker and extension officers, a course on cotton production for Agricultural Officers was held, and a 16 mm. cine film and other visual aids prepared.

TABLE I

Timing of Insecticide Application Trials

(Yield of seed cotton per acre and percentage damaged seed cotton) (in pounds)

Experimental Layout: Randomized blocks: 4 replications

Plot size: 1/10th acre (Gatooma and Chitala), 1/20th acre (Mt. Makulu), 1/30th acre (Sabi)

	Treatment (see text)	Locality of Trial									
		Gatooma			Sabi			Chitala		Mount Makulu	
		Yield	% damaged	Yield	% damaged	Yield	% damaged	Yield	% damaged	Yield	% damaged
K a s i	Unsprayed	—	—	1,897	20.9	552	16.6	1,118	33.9	—	—
	"Blanket" application	1,739	4.5	2,739	8.2	1,609	2.8	2,128	8.7	—	—
	8 weekly applications	598	17.1	2,386	10.6	874	7.9	1,326	26.6	—	—
	12 weekly applications	1,008	9.5	2,716	7.5	1,437	2.9	1,752	21.9	—	—
	4 weekly + 4 fortnightly applications	416	20.5	2,287	10.7	1,079	3.0	1,688	22.3	—	—
	8 fortnightly applications	396	13.2	2,344	8.4	—	—	—	—	—	—
	4 fortnightly applications	—	—	—	—	837	5.8	1,277	25.7	—	—
	Applications as per rainfall	1,400	7.9	—	—	—	—	—	—	—	—
	8 weekly applications	—	—	—	—	1,021	4.9	—	—	—	—
	L.S.D. 5% level	170	7.3	452	0.5	251	0.7	292	11.4	—	—
Dust											

$$.u\psi\psi\psi M = M$$
$$C = C_{\text{mid}};$$

$2 = 25p1$;

25111530J 5610036U=U

[illegible]

Timing of Insecticide Application Trials (Entomological Data)

CLUBS II

TABLE III

Relative Effectiveness of Sevin, DDT, and Thiodan Sprays and Sevin Dust (Gatooma)

Experimental Layout: Randomized Blocks: 4 replications: Plot size 1/10th acre

Treatment	Yield (lb. seed cotton per acre)	Percentage damaged seed cotton	Mean No. of Boltworm Eggs per plant		Mean No. of Boltworm Larvae per plant			No. of Diparopsis overwinter- ing pupae per sq. yd.
			Diparopsis	Heliothis	Diparopsis	Heliothis	Earias	
Sevin 0.5 per cent. (85% Sprayable) ..	924	10.3	1.05	17.67	0.10	4.85	0.10	0.05
DDT 0.5 per cent. (25% EC) *	1,595	7.1	1.30	15.75	1.20	1.50	0.40	0.25
Sevin 0.25% + DDT 0.25 per cent. (85% S + 50% WP) ..	1,334	8.3	1.12	11.90	0.20	1.60	0.70	0.05
Thiodan 0.5 per cent. (35% EC)	1,609	7.2	1.02	22.67	0.15	0.95	0.05	0.15
Sevin 5 per cent. dust (bag) ..	428	12.7	1.32	8.70	0.10	4.50	0.05	0.15
Sevin 5 per cent. dust (Kestrel)	626	10.6	1.20	8.77	0.05	6.85	0.15	0.20
L.S.D. 5 per cent. ..	268	3.4	n.s.	8.06	0.60	2.2	n.s.	n.s.

* plus two applications of Rogor for aphid control.

TABLE IV
Red Spider Mite Spray Trial (Sabl)
 Experimental Layout: Randomized Blocks: 4 replications: Plot size 1/80th acre

<i>Treatments</i> (last application—23/1/61)	<i>Yields</i> (lb. seed cotton per acre)	% Leaves infested with Red Spider Mite			% Plants with aphids present		
		21/1/61	4/2/61	4/3/61	21/1/61	4/2/61	4/3/61
Sevin 0.5 per cent.	2,062	12.3	41.6	16.4	50	100	75
Sevin 0.25 per cent. + DDT 0.25 per cent.	2,585	12.0	30.2	60.7	15	40	90
Sevin 0.5 per cent. + Rogor 0.1 per cent. *	2,238	0.6	2.1	76.6	0	25	85
Sevin 0.5 per cent. + Tedion 0.1 per cent. . .	2,208	0	5.3	96.3	55	85	85
Sevin 0.5 per cent. + Rogor 0.1 per cent. . .	2,297	0.2	0	34.7	0	10	60

* Rogor only applied for six applications.

TABLE V
Yield Data Extension Trial Plots 1960-61

	Plot No.	Yield (lb. s.c/ac.)			% damaged cotton		Area used for yield determination	
		Sprayed	Unsprayed	Increase	Sprayed	Unsprayed	Sprayed	Unsprayed
Nyasaland: Southern Province	1	1,795	1,200	595	5.6	31.1	0.23	0.25
	2	1,586	991	595	8.7	29.0	0.27	0.26
	3	1,306	702	604	0.8	10.6	0.66	0.66
	5	1,298	558	740	4.0	30.6	0.64	0.90
	7	1,058	918	140	4.2	13.5	0.43	0.36
	8	1,371	1,278	93	1.4	3.8	0.74	0.79
	9	1,075	576	499	3.6	14.6	0.52	0.48
	11	2,132	863	1,269	1.1	9.2	1.14	1.10
	12	2,486	1,582	904	9.3	15.6	1.02	0.99
	13	2,533	1,996	537	7.0	11.4	1.06	1.06
	22	1,128	396	733	4.9	20.5	1.11	0.96
	23	682	343	339	8.1	20.0	0.80	0.64
	24	933	609	264	31.6	59.7	1.40	1.40
	25	620	132	488	18.9	34.9	1.60	1.56
	26	533	88	445	43.7	67.4	1.60	1.60
	27	1,260	760	500	19.1	44.2	0.53	0.60
	Mean	1,285	742	543	10.2	20.9	0.85	0.85
Central Province	36	1,467	235	1,232	6.0	19.5	0.60	0.60
	38	1,092	709	383	2.6	12.0	0.70	0.70
	39	1,305	626	679	2.7	16.8	0.82	0.82
	40	1,335	489	846	4.3	27.3	0.54	0.54
	41	862	296	566	4.6	19.0	0.30	0.30
	42	601	234	367	12.0	45.1	0.38	0.38
	46	1,374	589	785	3.3	12.6	0.82	0.82
	47	1,382	619	763	4.6	11.5	0.53	0.53
	48	945	831	114	3.7	11.8	0.41	0.41
	49	1,763	902	861	5.9	13.0	0.11	0.11
	50	1,371	665	706	6.7	17.4	0.11	0.11
	51	1,548	180	1,368	2.6	31.3	1.25	1.25
	52	1,025	130	895	5.4	25.4	0.62	0.62
	Mean	1,264	448	816	4.4	17.1	0.55	0.55

TABLE V—(Continued)

Yield Data Extension Trial Plots 1960-61

Plot No.	Yield (lb./c(ac.))		Increase	damaged cotton		Area used for yield determination	
	Sprayed	Unsprayed		Sprayed	Unsprayed	Sprayed	Unsprayed
<i>Southern Rhodesia:</i> Low Veld	2,870	1,868	962	15.8	72.8	0.13	0.13
	1,686	1,352	334	24.7	100.0	0.50	0.50
	847	570	277	20.3	36.7	0.12	0.12
	1,225	1,460	-235	53.2	73.6	0.14	0.14
	1,657	1,104	553	4.7	7.8	0.12	0.12
Mean	1,660	1,312	348	28.9	69.3	0.20	0.20
High Veld	2,503	579	1,924	2.4	43.1	0.24	0.24
	1,463	39	1,424	4.8	53.7	0.24	0.24
	2,282	948	1,334	5.8	51.0	0.09	0.09
	1,073	33	1,040	10.8	52.7	0.21	0.21
	2,176	1,322	854	7.0	45.3	0.52	0.52
Mean	1,939	724	1,215	5.9	45.6	0.26	0.26
<i>Northern Rhodesia:</i> Overall	1,353	1,127	226	13.5	18.4	0.09	0.09
	1,331	676	655	9.5	27.1	0.58	0.58

* = Irrigated.

** = Supplementary irrigation.

Yields are from whole subplots in Nyasaland. In Southern and Northern Rhodesia yields are based on sampling areas only, where subplot acreages, except for Plot 8, varied from 0.5 to 1.5 acres. Plots 6 and 7 showed no difference in yield between sampling areas and whole subplots. On the remaining plots in Southern Rhodesia the appearance of the cotton was uniform over the whole of the subplots and it is unlikely that yields from these areas differed greatly from those of the sampling areas.

NOTE: Plot numbers refer to actual numbers used during the trial. Lack of sequence in the numbering of plots in Nyasaland arose through plots having to be discarded for various reasons prior to spraying.

ANNUAL REPORT OF THE TEA RESEARCH STATIONS OF NYASALAND AND RHODESIA 1960/61

Joint Tea Research Committee

<i>Chairman</i>	..	R. W. KETTLEWELL, C.M.G., B.SC. (Reading), DIP. AGRIC. (Cantab.), A.I.C.T.A.
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Leave—Senior Staff

I. P. SCARBOROUGH	..	U.K. Leave, August/October, 1960.
G. A. BRIDGER	..	U.K. Leave, December/February, 1960/61.
G. F. CRASKE	..	U.K. Leave, March/May, 1961.

Acknowledgements

Once again it is my pleasant duty to thank, in brief, the many people who have assisted the staff throughout the year.

I have had continued support and active help from the Tea Research Committee and the Finance Committee and without their backing, the work of the stations would have undoubtedly suffered. The Association members have shown their continued confidence in the work of the stations and their encouragement provides an undoubted stimulus.

There has been no change in the number of estate experiments and it is with great pleasure that I record once again my very grateful thanks to those managers who are put to so much trouble by us in the running of these experiments.

The specialist staff of the Department of Agriculture have undertaken more research and advisory work than ever before and form an essential and indispensable part of our team. My most sincere thanks are therefore due to the Director of Agriculture and to the members of his Department who gave us this assistance.

Finally, acknowledgement must be given to the Federal Minister of Agriculture who has offered all help that he can from the Department of Specialist Services. During the year three experts visited the tea areas at the request of the Research Committee. Drs. West and Thompson carried out a comparative soil and ecological survey between Nyasaland and Rhodesia. Mr. Martin's visit brought to light the damage caused by nematodes, particularly in nurseries.

D. H. LAYCOCK

Introduction

Unless otherwise stated this report refers to the crop season July, 1960, to June, 1961. Throughout, the labour supply was adequate for all purposes.

The rate of progress, both in research and advisory work, forecast in the last report has not only been maintained but accelerated. So rapidly in fact, that the quantity of work initiated will mature beyond the capacity of the present staff to manage and gives rise for concern. Either new staff will have to be appointed or judicious reductions made in the research programme.

The Agronomy Section has not produced new results of fundamental importance during the season and the essential but dreary process of collecting long-term data carried on, in its unspectacular way. The first of a new series of field experiments were planted at Mimoso and Cholo, and fuller detail is given in the body of the Report. Development of the sub-station in Cholo is proceeding apace and first trial yields are expected in 1962 although other data will be recorded before then.

The Plant Improvement Section has made vigorous and rapid pleasing progress. The work of the Plant Breeder has been comparatively wide but some emphasis has necessarily been placed on exploratory investigations rather than on full time selection or creative plant breeding as such. Vegetative propagation to the end of the nursery stage is well beyond the developmental phase and with the pot rank it was possible to transplant to the field the first reasonably large quantities of plants grown from cuttings. Thus begins the second stage in these investigations—a search for factors affecting survival in the field following transplanting from the nursery. Budding and grafting studies have been started and if successful, these offer a potentially powerful weapon in the Plant Improvement armoury.

All staff have undertaken advisory work, the demands for which have at times proved embarrassing to the research programme. This is not an unusual picture to be recorded in an annual report of a tea research station but providing future requirements do not seriously increase beyond their present level then there are great advantages and stimulation to be gained from personal contact with estate problems.

As a result of water and soil conservation propaganda and demonstration areas on the stations, there has been a remarkable demand for the services of the Senior Soil Conservation Officer of the Department of Agriculture. One officer was posted to the tea areas during the early part of the year and by the end he was finding that requests for his services and for his heavy machinery were as much as could be managed.

Mr. Martin, Senior Helminthologist of the Department of Specialist Services, carried out a survey of eelworm damage in Nyasaland and Rhodesia. This was particularly useful as it enabled positive identification to be given to a cause of poor nurseries which had been first suspected by the Plant Pathologist. The Plant Pathologist of the Department of Agriculture has consequently started experiments on fumigating nursery areas. Fortunately no serious infections have so far been found in mature tea growing in the field and the indications are that the problem is largely, if not entirely, confined to plants of nursery age.

Diseases have not been a serious problem during the season. However, the first serious outbreaks of the Gelatine Grub (*Niphadolepis alianta*) recorded since 1939, caused considerable damage and concern in isolated but fortunately comparatively small areas. Little is known about the survival of this pest and some concern is felt for the forthcoming season. The Entomologist of the Department of Agriculture directed control operations and took the opportunity to try some new insecticides as will be detailed in his report. Cool and cloudy weather at the end of the rains caused the worst outbreak of Mosquito Bug (*Helopeltis bergrothi*) experienced for a number of years.

The Tea Research Committee met five times between July, 1960, and August, 1961.

Concern was expressed by a small number of Association members over expenditure on the stations. This led to Professor Phillips inquiring into the activities of the station during August, 1961, and his report undoubtedly justifies the research programme and the expense involved.

REPORT OF THE AGRONOMY SECTION

Pruning and Tipping Experiments

(i) PRUNING CYCLES ON LOCAL JAT TEA, THORNWOOD ESTATE

At the end of the season this experiment had completed nine successive seasons of treatments. Average yield per season for the nine seasons is given in table 1 according to length of pruning cycle.

TABLE 1
Yield in lb. m.t.p.a. according to pruning cycles, Thornwood Estate

	Pruning Cycle			L.S.D.	
	yearly	2 yearly	3 yearly	0.05	0.01
Average per season	1,059	1,078	1,037	none	none

C.V. per cent., nine seasons, 15.74

There are no significant differences between main treatment effects due to pruning cycle but of far greater importance is the indication of the interplay between length of cycle and nitrogen rate. Table 2 records the 5 year running averages according to time, pruning cycle and nitrogen rate.

TABLE 2
5 year running averages according to length of pruning cycle and nitrogen rate lb. m.t.p.a.

Season	Annual Prune with :			2 Yearly Prune with :			3 Yearly Prune with :		
	N40	N80	N120	N40	N80	N120	N40	N80	N120
1955/56 ..	1,017	1,129	1,285	907	1,045	1,228	923	1,156	1,325
1956/57 ..	903	1,087	1,310	844	1,082	1,334	799	1,124	1,400
1957/58 ..	823	1,028	1,269	732	995	1,297	662	1,017	1,324
1958/59 ..	808	1,048	1,333	799	1,090	1,485	718	1,155	1,520
1959/60 ..	757	1,017	1,303	707	1,012	1,432	670	1,120	1,542
1960/61 ..	723	993	1,293	738	1,072	1,534	533	1,085	1,437

Forty lb. of nitrogen (N) per acre appears to be insufficient to maintain yield under any cycle. The loss is greatest under the 3 yearly cycle. N80 under each cycle is probably holding yield fairly constant or causing only a slight downwards trend. N120 under the two extended cycles is increasing the trend.

Tipping at 2, 4 or 6 inches after prune, followed by plucking to the janum once the table is formed, has not caused significant differences in average yields. Significant increases in yield, as might be expected, are obtained by the lower tips during the tipping phase following prune, but these are small and are lost during the remainder of the main crop season.

Table 3 records the 5 yearly running averages according to tipping height and nitrogen rate,

TABLE 3

Five yearly running averages according to tipping heights and nitrogen rate

Season	2" tip with:			4" tip with:			6" tip with:		
	N40	N80	N120	N40	N80	N120	N40	N80	N120
1955/56 ..	1,031	1,152	1,275	954	1,107	1,251	865	1,076	1,312
1956/57 ..	929	1,140	1,347	865	1,091	1,312	753	1,062	1,381
1957/58 ..	812	1,057	1,292	763	992	1,265	646	991	1,322
1958/59 ..	869	1,159	1,436	797	1,071	1,414	662	1,064	1,488
1959/60 ..	813	1,120	1,404	726	1,013	1,404	598	1,016	1,469
1960/61 ..	764	1,070	1,376	682	975	1,410	549	1,005	1,478

Regardless of tipping height N40 has not maintained yield. The bias due to pruning year is not so pronounced in the above table as in the former and it is possible that N80 is slowly losing ground. Both tables would suggest that this nitrogen rate is near to the balancing point of lowering or increasing trends. The highest nitrogen rate is most probably causing increasing trend.

Although not statistically conclusive (due to the higher standard errors obtained with estate experiments as opposed to station experiments) the two tables indicate that N40 regardless of cycle or tipping height is insufficient to maintain yields. N80 might be near to the maintenance level but N120 is most probably causing an upward trend. The beneficial effect above N80 is possibly linked with providing adequate maintenance foliage in the top hamper. Both longer cycles and higher tips would both cause denser top hampers. This is in agreement with Eden's finding in Ceylon.

The simple interplay between length of pruning cycle and tipping height has not caused any obvious trends with the moving averages but it will be appreciated that these are taken from an average nitrogen level of N80.

After 9 successive tips at 2 inches above the annual prune it became impossible to clean prune in any reasonable manner and thus the annually pruned plots were lightly down pruned at the end of the season.

(ii) EFFECT OF TYPE OF PRUNE ON THE YIELD OF IMMATURE TEA

Two contrasting pruning methods were compared for the second year in succession in one experiment on tea, seven years old. The first is to give the conventional type of clean prune at the desired height, removing crossed branches, dormant shoots and dead branches. The second is a simple cut across prune at the same height but without any cleaning whatsoever thereafter.

Yields for the past season are given in table 4.

TABLE 4

Effect of pruning method on the yield of young tea, lb. m.t.p.a.

	Pruning method		L.S.D.
	Clean	No clean	P=0.001
Yield 1960/61	1,125	1,281	150

C.V. per cent., 1960/61, 8.49

A highly significant increase in yield has been caused by the lighter prune.

This experiment also includes three fertilizers (N.P.K.) each at two different levels, but there was no significant increase in yield due to fertilizers alone or in combination with pruning method.

(iii) OTHER PRUNING EXPERIMENTS

The Swazi long term experiment completed its twentieth successive year of treatments and will be reported on next season. The first of the complex experiments at Mimosa received its "time of prune" treatments overlapping the end of the season but first treatment effects will not be available for analysis until 1962. Similarly, times of prune treatments were introduced into the Gotha experiment at the end of the present season.

Plots of young tea were pruned at monthly intervals during the first half of the 1960 dry season to examine the effects on protecting young tea against drought. This was abortive because no drought ensued although the later prunes produced more turgid looking bushes at the end of the dry season. But in contrast, total yield was reduced for the following season by the later pruning times.

Fertilizer Experiments

This section deals with fertilizers applied to unshaded tea planted at one spacing in any one experiment. The interplay of fertilizer with other management methods is reported in other sections.

(i) N.P.K. EXPERIMENT ON YOUNG INDIAN TEA, MIMOSA

This experiment was planted in 1953 and has been given increasing rates of fertilizer until the maximum was applied in 1959. Treatments applied during the season were:

Sulphate of ammonia supplying 40 or 80 lb. N. per acre.
Single superphosphate supplying 0 or 30 lb. P_2O_5 per acre.
Muriate of potash supplying 0 or 30 lb. K_2O per acre.

These fertilizers caused no significant differences in yield.

The majority of experimental evidence collected, points to nil or very low responses to N.P. or K. from young tea planted on virgin red soils in good heart. Significant responses to nitrogen are usually not obtained until about the tenth year. On the other hand a lack of sulphur, particularly in the first two years following planting, consistently produces deficiency symptoms throughout all areas and applications of sulphur-bearing fertilizers are essential during the early years. Sulphate of ammonia provides a convenient carrier for sulphur.

(ii) THREE CUBED FACTORIAL N.P.K. EXPERIMENTS ON MATURE INDIAN TEA, SWAZI (MLANJE), AND NAMIREME ESTATE (CHOLO)

These two experiments have identical fertilizer treatments on equivalent tea but differ in that one is in the wetter and more congenial Mlanje District and the other in drier conditions in Cholo. The experiments compare in factorial combinations the effects of three rates of each of the major fertilizers.

Yields according to treatments are given in table 5.

TABLE 5

Effect of N.P.K. on yields of mature tea at Swazi and Namireme, lb. m.t.p.a.

Nutrient	N			P_2O_5			K_2O			L.S.D.	
lb. per acre	40	80	120	0	30	60	0	30	60	0.05	0.01
Swazi	678	1,020	1,377	1,000	1,015	1,060	994	1,052	1,029	119	162
Namireme	420	553	708	569	544	568	554	576	550	51	70

C.V. % Swazi, 10.72
C.V. % Namireme, 13.29

At both sites, increasing nitrogen rates have caused highly significant increases in yield. At neither station has phosphate nor potash significantly affected yields.

The responses parallel previous years and are much lower under the drier Namireme conditions:

TABLE 6
Return in lb. m.t. for each added lb. of nitrogen (N)

	From N40 to N80	From N80 to N120	Mean
Swazi	8.55	8.90	8.72
Namireme	3.32	3.87	3.59

(iii) SULPHATE OF AMMONIA ON LOCAL JAT TEA, THORNWOOD ESTATE

The possible interplay of nitrogen with length of pruning cycle and tipping heights has been described in a previous section. Tables 7 and 8 show average returns obtained over the nine years according to pruning cycles and tipping heights.

TABLE 7

		Pruning cycle			Mean
		yearly	2 yearly	3 yearly	
Return lb. m.t.	From N40 to N80	5.50	6.70	9.37	7.19
	From N80 to N120	6.85	8.87	8.50	8.07
Mean for cycle		6.17	7.79	8.94	—

TABLE 8
Return in lb. m.t. for each added lb. of nitrogen (N) according to tipping height

		Tipping height			Mean
		2"	4"	6"	
Return lb. m.t.	From N40 to N80	6.20	6.20	9.17	7.19
	From N80 to N120	6.62	7.90	9.67	8.07
Mean for height		6.41	7.05	9.42	—

Longer cycles and higher tipping heights increase the returns from nitrogen. These tables, as suggested previously, illustrate that increasing efficiency is obtained from nitrogen applications when the bush is encouraged by other management methods to develop a dense top hamper. Longer cycles with higher tipping will both encourage this aim.

The mean responses to nitrogen when averaged over other treatments are in accordance with those obtained from Swazi.

(iv) TWO CUBED N.P.K. EXPERIMENTS AT LAUDERDALE ESTATE (MLANJE) AND BANDANGA ESTATE (CHOLO)

These experiments, sited on very old gardens, compare identical fertilizer treatments which are:

Sulphate of ammonia supplying 0 or 80 lb. N. per acre.
Single superphosphate supplying 0 or 60 lb. P_2O_5 per acre.
Muriate of potash supplying 0 or 60 lb. K_2O per acre.

At both sites nitrogen has caused highly significant increases in yield. Neither phosphate nor potash applications have caused significant differences. At Bandanga the return in made tea for each added pound of nitrogen was 4.25 and compares with that from Namireme of 3.32. No responses are calculated for Lauderdale because the experiment is not recorded at every plucking round.

(v) TYPES OF FERTILIZER EXPERIMENT, MIMOSA

In previous reports this experiment has been called, "Urea versus Sulphate of Ammonia". The title has been changed to be more accurately descriptive of the other treatments which are now included. At the start of the past season the tea was nine years old and unshaded. The increase in yield between sulphate of ammonia supplying 40 lb. N. and 80 lb. N. was small but statistically significant at $P=0.05$. Urea with or without sulphur and calcium ammonium nitrate have not caused significant difference.

It is expected that some years will elapse before consistent information is obtained from this experiment.

Spacing Experiments

(i) GENERAL

All past season's yield data from all spacing experiments fit the asymptotic curves described in the 1959/60 Report. No further comment can be made on spacing effects. In no experiment has any interaction occurred between spacing and nitrogen rate, but the oldest tea in the factorial series of experiments was only nine and half years old at the end of the season.

Differences due to nitrogen rates have not been found to be great or highly significant until the tea reaches 10 years or more in the field. Three experiments, planted in yearly sequence were 8.5, 7.5 and 6.5 years old at the end of the season. In each, nitrogen, as sulphate of ammonia was applied at 40, 80 or 120 lb. N. per acre but caused no significant differences in yield.

In the oldest experiment (9.5 years) sulphate of ammonia supplies the equivalent of 40, 80, 160 and 240 lb. N. per acre. Yields according to these rates are given in table 9.

TABLE 9
Yield according to nitrogen rate, lb. m.t.p.a.

Nitrogen rate	..	..	..	40	80	160	240
lb. m.t.p.a.	..	..	..	1,341	1,393	1,132	1,366

The differences are small and not significant. A drop in yield will be noted between N160 and N240. All yields fit significantly onto a quadratic curve, $Y = 1249 + 2.45N - 0.0082N^2$, where Y is the yield in lb. m.t.p.a. and N, the nitrogen rate. The r^2 value between observed and calculated yields is 0.9968 and is significant at $P=0.01$. The equation yields at turning point at N150, above or below which yields decrease. It is not possible at present to regard this as anything more than an indication. It may be a real effect or it may be nothing more than a fortuitous arithmetical agreement. Time alone will provide more conclusive data.

Permanent Shading of Tea

(i) SHADE TREES AND N.P.K., MIMOSA

In this experiment in the Mlanje District, the effects of three permanent shade trees are compared with unshaded tea and superimposed under the shade treatments are four nitrogen rates with or without phosphate and potash. The tea was 9.5 years old at the end of the season.

Yields according to shade treatments are given in table 10.

TABLE 10

Yields in lb. m.t.p.a. according to shade treatment and age from planting

Season	Shade species				L.S.D.	
	<i>Glyricidia maculata</i>	<i>Albizzia gummifera</i>	<i>Grevillea robusta</i>	No shade	P=0.05	P=0.01
1960/61	974	932	1,246	1,451	366	573
1953/60	4,123	4,451	5,542	5,648	—	—
TOTAL	5,097	5,383	6,788	7,099	—	—

During the past season *Glyricidia* and *Albizzia* have significantly reduced yield in comparison with *Grevillea* and no shade. There are no significant differences within these pairs of treatments.

Fertilizers have caused no significant differences. The interaction of phosphate under *Grevillea* mentioned in last year's Report has not proved significant this season.

(ii) OBSERVATION PLOTS, SWAZI

Recordings continue to be made under the non-replicated plots of mature tea at Swazi, shaded with and without mature *Albizzia gummifera* trees or young *Grevillea robusta* trees. Half of each shaded plots receives no fertilizer and the remaining half the equivalent of 80 lb. N. p.a. as sulphate of ammonia. The tea was in its third and last year from prune during the season.

Yields for the past season are given in tables 11 and 14.

TABLE 11

Yields in lb. m.t.p.a. under *Albizzia gummifera* shade

				Albizzia		Mean for nitrogen
				Without	With	
Without nitrogen	..	..		306	735	520
With 80 lb. N. p.a.	..	..		802	864	833
Mean for shade	..	..	..	554	799	—

A similar pattern is repeated to that recorded in previous seasons. *Albizzia* alone has increased yields but has had a depressing effect on response to nitrogen. Without shade each pound of added nitrogen has yielded 6.20 pounds of tea but under shade the return is reduced to 1.61 pounds.

The observation in its present form has been recorded for three successive three-year pruning cycles. After clean prune the tea remains entirely unpruned for the following three years. In May, 1955, the bushes were very heavily down pruned. Average yields according to treatment and to the sequence from prune were calculated from the three cycles and are recorded in table 12.

TABLE 12

Average yields lb. m.t.p.a. according to shade, nitrogen level and year from prune

Year from prune	First			Second			Third		
	Albizzia		N. Mean	Albizzia		N. Mean	Albizzia		N. Mean
	—	+		—	+		—	+	
Without nitrogen	510	554	532	548	778	663	301	582	441
With nitrogen	708	653	680	982	959	970	682	702	692
Mean for shade	609	604	—	765	868	—	492	642	—

In table 13 the above data are transformed into percentages of the no shade no nitrogen yield for each year.

TABLE 13

Percentage comparisons between yields according to shade, nitrogen level and year from prune

Year from prune	First			Second			Third		
	Albizzia		N.	Albizzia		N.	Albizzia		N.
	—	+		—	+		—	+	
Without nitrogen	100	109	105	100	142	121	100	193	146
With nitrogen	139	128	133	179	175	177	227	233	230
Mean for shade	119	118	—	139	159	—	163	213	—

Both *Albizzia* and nitrogen increase in effectiveness as the cycle progresses and this confirms what had been suspected in previous years. *Albizzia*, in any year of the cycle, reduces response to nitrogen in comparison with no shade.

Yields from exactly the same tea but shaded with young *Grevillea robusta* trees are recorded in table 14. The shade trees, planted in December, 1955, have made slow growth because of competition with the mature tea and they do not yet offer a shade canopy as is usually seen under mature *Grevillea*.

TABLE 14

Yields in lb. m.t.p.a. under *Grevillea robusta*

	Grevillea		Mean for nitrogen
	Without	With	
Without nitrogen	307	403	355
With 80 lb. N. p.a.	977	958	967
Mean for shade	642	680	—

Nitrogen with and without shade has caused high yield increments. The density of the shade cast by the *Grevillea* is as yet small and the increment due to this treatment is slight and must remain subject to doubt until the trees are older.

Shelter

SHELTER AND YIELD

A prototype investigation, designed to test the effect of shelter on the yield of tea, was started in 1959. Six widely separated plots, each of 100 bushes, were recorded for yield over 25 plucking rounds from January, 1959, to June, 1960. The tea is unshaded. Two of the plots thereafter received no shelter treatment, two were surrounded in July, 1960, by 12 foot high camouflage nets with the scrim removed and the remaining two with nets plus scrim. Three anemometers were available and were rotated round the plots at weekly intervals before and after the nets were erected. Yield and wind run data were examined for the two periods January to June, 1959, and July to May, 1961. The experimental method depends upon the expectation that the regressions for the untreated control plots, for both yield and wind run, will not alter significantly between the uniformity period and the treatment period. This in fact has happened, apart from an increase in the constant term in the yield equation due to increasing age, and thus it is possible to calculate with some confidence from the uniformity equations, the yield and wind run expectation had treatments not been imposed on the remaining plots. These values were compared with the actual values recorded.

The nets alone have had no significant effect on wind run which is perhaps opposed to European experience. This is possibly due to comparatively low wind runs obtained in Mlanje which average about 55 miles per day during the rainy season and the early dry season, rising to some 70 or 80 miles per day during the last four weeks of the hot dry season immediately before the rains. The nets plus scrim significantly reduced wind run by a calculated average of 48 per cent. but the effect is not linear and appears to become proportionately higher as the wind speed increases.

The unsheltered plots have yielded 10 per cent. more than would have been expected from the uniformity regression and this is due to increasing age of the tea; the tea is still immature. The plots surrounded by nets alone gave a 27 per cent. increase in yield over expectation and those with nets plus scrim 28 per cent. This result is perplexing. Both series, surrounded either by nets alone or nets with scrim, have yielded equally beyond uniformity expectation but nets alone have had no significant effect on wind run. No reason can be given.

Although the experiment has not yielded practical results in which any confidence can be placed the success of the underlying experimental method, that of successfully being able to predict the behaviour of plots from a calibration period, offers possibilities and it may be worthwhile to repeat the exercise but with considerably more replications and replacing the net alone treatment with something better designed to cause a second level of shelter effect.

The existing plots will be recorded for at least one more season.

The nets cast virtually no shade over the plots between 8 a.m. and 4 p.m.

Irrigation Studies

(i) THORNWOOD ESTATE, MLANJE

Three adjacent areas of tea were chosen at Thornwood estate. The tea, very old local jat with an average population of 1,550 plants per acre, was chosen because it was near to water and near to the station for supervision. A yield calibration period was conducted before irrigation started in May, 1959. Each irrigated area is 0.31 acres. Throughout the dry season two rates of irrigation were supplied by overhead sprinkler. The first was equivalent to the evaporation in inches from a standard pan less incoming rain and the second, half the quantity of water applied by the first rate.

The unirrigated plot was divided into two and harvested accordingly. The proportionate differences between the two halves do not differ significantly between the calibration period and thereafter, which enables the increase in yield due to irrigation to be estimated with some confidence (*see* shelter experimental method, above).

During the 28 weeks, 1st May, 1960, to mid-November, 1960, 24 inches of water were applied at the highest level of irrigation and 12 inches at the lower rate.

Yields according to irrigation are given in table 15 and are adjusted according to calibration data.

TABLE 15
Yields, lb. m.t.p.a. according to irrigation rate, Thornwood Estate

Irrigation inches	nil	12	24
Yield lb. m.t.p.a.	532	676	710
Increase lb. m.t.p.a.	—	144	178
Per cent. increase	—	27	33

It would be unwise to base conclusions on data from only one year's trial and the trial is being repeated during 1961.

It is of interest to note that in the Lujenda experiments, recorded below, the irrigated section, which received the equivalent of one inch of water per week by overhead spray during the dry season yielded 28 per cent. more crop than the unirrigated section. This is in agreement with the equivalent at Thornwood considering the limitations imposed by practical difficulties on experimental design, but again more information is required before drawing firm conclusions.

(ii) IRRIGATION EXPERIMENTS, LUJENDA ESTATE (CHOLO DISTRICT)

Two adjacent areas were placed at the disposal of the stations for experimental purposes at Lujenda Estate situated in one of the drier areas of Cholo District. The first area is irrigated at one inch per week throughout the dry season by overhead spray and the second is not irrigated. After calibration periods the following treatments were applied in factorial combination, starting at May, 1960:

Sulphate of ammonia supplying the equivalent of 80, 120 or 160 lb. N. per acre.

These rates were applied by three different methods:

- (i) whole rate in late October;
- (ii) half rate in late October and remainder in early January;
- (iii) one third in late October, one third in early January and the remainder in early May.

The first season's yields are given in table 16 and these have been adjusted on calibration yields by the analysis of covariance.

TABLE 16
Yields in lb. m.t.p.a. according to treatments and irrigation, Milango Estate

				Nitrogen lb. N. p.a.			Method of application		
				80	120	160	All Oct. — —	$\frac{1}{2}$ Oct. $\frac{1}{2}$ Jan. —	$\frac{1}{3}$ Oct. $\frac{1}{3}$ Jan. $\frac{1}{3}$ May
Irrigated				1,614	1,670	1,735	1,654	1,653	1,712
Unirrigated				1,176	1,236	1,225	1,200	1,204	1,233

The increments due to increasing nitrogen rates for the irrigated tea, although as yet comparatively small, are significant. The differences under no irrigation are not significant. Dividing the fertilizer into three, has caused a significant increase in crop under irrigation but not with the unirrigated tea.

Past experience would indicate that at least three years must pass before residual effects from pre-experimental fertilizers are lost and the treatments become stabilized.

(iii) EFFECT OF IRRIGATION ON CROP DISTRIBUTION

Although it would be unsound to offer conclusive remarks on crop distribution after only one season's experimental work there was no evidence gained to suggest that irrigation will materially increase crops during the cool dry season. Much of the comparative increase in crop at both the sites was harvested during the first heavy November/December flush of the rainy season. If this trend is substantiated in future then irrigation might make estate management even more difficult than it is at present unless alternative field management methods can be evolved to even out crop distribution.

Arboricides

In continuation of the trial reported on last year, observations were continued and show that in general 2.4.5-T is a more toxic arboricide than 2.4-D. TBA as used in these trials was of no use on the species inoculated.

Visual results are given in table 17 and treatments imposed on four trees of each species were:

- (i) Untreated control plants.
- (ii) Conventional ringbarking.
- (iii) 2.4-D; 5 per cent. solution in diesel oil applied into a frill at 20 c.c. per inch of girth.
- (iv) 2.4.5-T; 5 per cent. solution in diesel oil applied as for (iii).
- (v) T.B.A.; 2 per cent. aqueous solution applied as for (iii).

TABLE 17

The effect of ringbarking and three arboricides on indigenous tree species 21 months after treatment

Species	Control	Ringbark	2.4-D	2.4.5-T	TBA
<i>Uapaca kirkiana</i>	Normal growth	Dying	All dead	All dead	Normal growth
<i>Cussonia kirkii</i>	Normal growth	All dead	All dead	All dead	Yellow
<i>Brachystegia</i> sp.	Normal growth	All dead	Two still have foliage	One alive	Yellow foliage
<i>Afromosia angolensis</i>	Normal growth	Yellow foliage	All dead one shoot at base	All dead	Normal growth
<i>Parinari mobola</i>	Normal growth	One tree alive and fruiting	One shooting at base	All dead	Normal growth
<i>Erythrina abyssinica</i>	Normal growth	All dead	All dead	All dead	Normal growth

All treated *Pterocarpus angolensis* trees have been uprooted for starch analysis.

THE USE OF ARBORICIDES ON GREVILLEA ROBUSTA

Three arboricides were applied by three methods to *Grevillea* trees at Minosa.

Arboricides used were 2.4-D and 2.4.5-T both dissolved in diesel oil or T.B.A. dissolved in water. Each was applied to the frill as follows:

(i) A 6 per cent. solution at the rate of 1 c.c. per inch of girth.

(ii) A 3 per cent. solution at the rate of 1 c.c. per inch of girth, followed by a similar application three months later.

(iii) A 2 per cent. solution at the rate of 1 c.c. per inch of girth, followed by two similar applications at two monthly intervals.

Thus trees received a total of 6 per cent. arboricide solution, in one, two or three doses. Treatments started in August, 1960, and the average girth of the trees at that time was 19.8 inches. Frills were made at 3 feet above ground level. Guard rows between plots were ringbarked in the conventional manner.

TABLE 18
Effect of arboricides on *Grevillea robusta* at 6 months

Arboricide and method of application	2.4-D			2.4.5-T			T.B.A.		
	3 × 2%	2 × 3%	1 × 6%	3 × 2%	2 × 3%	1 × 6%	3 × 2%	2 × 3%	1 × 6%
Numbers of trees treated ..	11	11	11	12	12	11	11	13	10
Trees dead with no shoots ..	2	—	—	8	3	—	—	—	—
Trees dead above frill but with shoots below ..	4	3	7	1	2	11	—	—	—
Canopy affected	3	—	—	3	7	—	—	—	—
Canopy not affected ..	2	8	4	—	—	—	11	13	10

Twelve months after treatment some ringbarked trees were dead but by this time it was clear that 2.4.5-T was a more effective killer than 2.4-D. T.B.A. has had no visual effect.

Table 19 records observations at 12 months after the start of the experiment.

TABLE 19
Effect of arboricides on *Grevillea robusta* at 12 months

Arboricide and method of application	2.4-D			2.4.5-T			T.B.A.		
	3 × 2%	2 × 3%	1 × 6%	3 × 2%	2 × 3%	1 × 6%	3 × 2%	2 × 3%	1 × 6%
Number of trees treated ..	11	11	11	12	12	11	11	13	10
Trees dead with no shoots ..	4	2	3	11	7	4	—	—	—
Trees dead above frill but with shoots below ..	5	6	5	1	5	7	—	—	—
Canopy not affected ..	2	3	3	—	—	—	11	13	10

2.4.5.T is clearly the most efficient of the three arboricides tested.

GENERAL

A comprehensive trial of T.B.A. on *Uapaca kirkii* (Musuku), common species on the Cholo Sub station, gave no results. In no trial has T.B.A. been found effective and it cannot be recommended.

Starch analyses on roots were made at intervals and full details will be found on these experiments in the Report of the Senior Agricultural Chemist. It can be said here that effects are most encouraging in that arboricides have frequently reduced starch contents equivalent to those obtained by ringbarking. Although differences exist between tree species and more work is required, 2.4.5 T shows every sign of being useful for shade thinning programmes with *Grevillea*.

Plant Improvement

PLANT BREEDER'S REPORT

(i) CONTROLLED POLLINATION

It was reported in this Annual Report for 1959-60 that a number of controlled pollinations had been made during 1960. These were mainly self pollinations performed on Tingamera and Betjan trees. It was found that from the Tingamera no viable self-pollinated seeds could be obtained. From the Betjan, although seeds were collected, only five were successfully germinated and these are now small plants and growing rather slowly.

No doubt part of this lack of success may be attributed to faults in technique but it would appear that self-pollination does not offer much hope of being an easy breeding method with tea. Some more self pollinations are being attempted this year but the main work during the 1961 season has been cross-pollinations of which about 2,000 have been made from mid-April until mid-July.

(ii) CLONAL SEED GARDENS

A small clonal seed garden has been established at Mimosa. This has been planted with five Betjan clones only, the clones having been selected as being good bright fermenters. The plants were transplanted into the field in March, 1961, approximately eight months after the cuttings were taken. Individual wigwam type painted polythene shades were placed over each plant on transplanting. A number of deaths have occurred but these will be replaced as more rooted plants become available.

In addition to these five clones another sixteen have now been selected on the basis of good bright fermentation from the Betjan seed bearers in isolation area No. 5 at Mimosa. All 21 clones are now being propagated under the mist unit and under polythene cloches at Swazi. Various combinations of these will be used for the establishment of further clonal seed gardens.

The main pollination work being carried out this year, as referred to above is cross pollinations between these 21 seed bearers in all possible combinations. This work should eventually yield positive information as to the sort of progeny likely to be produced by any combination of these clones.

(iii) FIELD SELECTIONS

During the past season some 275 bushes have been plucked on a strict 7 day round and their yields recorded. These bushes comprise the following:

Field 7 Swazi, 112 bushes India Hybrid Tea selected solely on early break away from prune.

Fields 12, 16B and 28 Swazi, 118 bushes Indian Hybrid Tea selected on early break away from prune, frame conformation and size, leaf type.

Fields 1-8 Mimosa, 21 bushes Indian Hybrid Tea selected primarily on survival in 1957 drought but since retained on basis of fermentation and rooting ability.

Field 9 Mimosa, 24 bushes Tingamera jat selected on frame conformation and size, leaf type.

All these bushes have been tested at least once and many several times, for fermentation by the chloroform test. 42 bushes have been assessed for theaflavin and thearubigin production in fermentation. Thirty bushes were manufactured individually on several occasions so that a reasonable sample of each was produced. A number of these teas have been considered favourably by experienced tea testers.

The yield of the bushes has again demonstrated the close general correlation between area and yield. However with area reduced to a constant, the yield of some bushes has been twice that of the general mean.

The yield of some individual bushes has been extremely high. For example S.F.S. 215, a bush of 21 square feet plucking area, yielded 12.11 lb. of green leaf over 31 plucking rounds from tipping on 5th September, 1960, until 9th June, 1961. This is equivalent to the high yield of 5,478 lb. of made tea per acre as compared with that of 1,677 for the field as a whole plucked commercially. These are early days in this study and no promises can be made that clones can be established which will yield anything like this figure. The signs are very promising however that the material does exist, upon which selection can be made.

From the data collected during the year some 28 bushes have been selected on the basis of yield and fermentation as being potentially useful for the establishment of field clones. They are now being allowed to grow up for the production of cuttings.

Field Trials

(i) ESTATES VARIETY TRIAL

This trial which sets out to compare the yield and quality of tea derived from the seed gardens of estates in Mlanje, Cholo and Rhodesia and also of three imported jats, was planted according to plan at Mimosa and Cholo Tea Research Stations. There were 23 treatments as follows:

From seed gardens in Mlanje	..	..	11
Cholo	..	..	7
East Africa	..	..	3
Rhodesia	..	..	1
Vegetatively propagated (mixed clones)			1

Very big differences were noticed in size and general appearance between the groups of stumps as they were received from the estates. This is presumed to be largely a reflection of differences in nursery sites and techniques. Those treatments where establishment is now poor, were in all cases those with poorly produced stumps. This includes two treatments where the stumps were 18 months old only, although one other treatment with exceptionally large 18-month-old stumps has established as well as any.

This opportunity is taken of emphasizing the paramount importance of producing first class planting material.

The vacancies in this trial will be infilled in the coming season and should yield very valuable information in the future.

(ii) JUNIOR VIGOUR TRIAL

The object of this trial is to discover measurable characters of juvenile plants which are carried through as expressions of vigour in the adult, thus enabling selection for vigour to be done more confidently at an early stage. The following seedling characters are measured:

- (a) Length of main stem
- (b) Diameter of main stem
- (c) Number of branches
- (d) Total length of branches
- (e) Number of leaves
- (f) Plant habit
- (g) Branching habit.

Fifty-six young plants of each of a number of seedling jats and clones are thus measured as they grow until they are planted out in the field in a yield trial.

The trial is planned to be repeated over three years. The first field planting was made in December, 1960. Unfortunately due to the great difficulty of keeping any sort of label on a plant in this area, this planting was not very successful.

(iii) TRIAL OF JUVENILE CHARACTERISTICS OF INDIVIDUAL BUSHES

One hundred two-year-old seedlings of Betjan and of a local jat of Indian Hybrid Tea were scored for the seven characters listed above in the Junior Vigour Trial. In addition the following characters were recorded:

- (h) Leaf shape (length to breadth ratio)
- (i) Length of largest leaf
- (j) Degree of colour
- (k) Degree of glossiness
- (l) Degree of dentation of leaf margin
- (m) Degree of embossing of leaf surface
- (n) Degree of pubescence of bud and first leaf.

During December, 1960, the bushes were planted out, half at Mimosa and half at Cholo Tea Research Station, and at each place half were planted with *Albizzia* shade and half without shade. As the bushes develop to maturity their characters will be recorded periodically. When they come into plucking and as they proceed towards maturity their yield will be recorded and tea manufactured from them individually.

It is hoped that eventually some concrete evidence will be obtained as to whether leaf shape and type of seedlings are reliable selection criteria.

(iv) METHODS OF INDUCING EARLY FLOWERING

The attempts to induce the early flowering of seedlings reported in this report for 1959/60 were continued, but without any positive results.

The attempt to increase day length by illuminating a 500 square feet nursery from dark until 10 p.m. with 11 ordinary 100 watt tungsten filament lamps has had no effect. It is thought probable that the light produced did not reach the threshold value required to produce day length effects.

A proprietary brand of Gibberellin was applied according to the maker's instructions to tea seedlings of from 6 months to 2 years of age, over a period of four months. **No special effects of any kind were produced.**

Miniature Manufacture

A great deal of work during the year was devoted to an attempt at perfecting the miniature manufacture of tea. The major difficulties were overcome and we can now manufacture small samples satisfactorily. Over 200 samples were manufactured. These consisted mainly of pluckings from individual bushes but some batches were manufactured in connection with the fermentation investigation.

Fermentation Investigation

A great deal of work was done during the season by the Plant Breeding section in conjunction with the biochemical investigation into tea fermentation. This is very much to be expected as apart from the generally complementary nature of the work of the two departments, the biochemical team has developed methods of testing for fermentation which will be of the greatest value to the plant breeding work.

Fresh leaf samples were sent to Cambridge as required during the period from January to June, 1961.

(i) ACETIC ACID TREATMENT OF TEA DURING MANUFACTURE

In the second Annual Report (1959/60) of the Cambridge biochemical investigation, Dr. Bendall records a laboratory experiment which showed that a slightly acidified medium enhanced the production of theaflavins in fermentation. He therefore suggested that the addition of small quantities of very dilute acetic acid to the tea at some stage in manufacture on a factory scale might produce a brighter if not a stronger tea. Accordingly a series of experiments were carried out in eight factories in Mlanje and Cholo during May and June, 1961. Two per cent. acetic acid at the rate of 144 c.c. per 100 lb. of withered leaf was sprayed on to the tea as it was fed into the first roll in manufacture. The smell of the acid was pronounced during rolling and the fermentation period, but was driven off completely during firing. One factory manager considered that he could detect the smell in the made tea immediately after firing but there was no suggestion at all of any taint being detectable in the tea when infused. In all cases the teas were compared by the factory managers themselves with untreated samples which were as nearly as possible comparable with the treated tea. In one factory only was the treatment conspicuously successful. Here the liquor of the acid treated tea was very much brighter and brisker and the infusion also was brighter than that of the control. In all other cases there was no really clear cut improvement effected by the acid treatment.

This matter will be investigated further as opportunity presents itself. If the success which appeared in the one instance could be repeated, the treatment would be very well worthwhile. The cost of the acid would be negligible especially if obtained in bulk and the method of application would present no difficulties.

(ii) INVESTIGATION INTO A POSSIBLE BORON DEFICIENCY

A report from East Africa of a boron deficiency disease of *Grevillea*s and an indication that this may also be present in Nyasaland, led to a suggestion that tea here may possibly be suffering from boron deficiency to an extent which impaired fermentation.

In order to test this, a block of five acres of nine year old Indian Hybrid tea was treated with a single dressing of 10 lb. agricultural borate per acre. A similar area adjacent was left untreated and used as a control. On eight occasions between September, 1960, and May, 1961, tea from the treated and untreated areas was manufactured in various factories in Mlanje, precautions being taken to standardize as far as possible the manufacture of the two samples. The teas have in all cases been reported upon by the London brokers. The results have been rather difficult to

interpret due to the balancing of one character against another in the reports. However on the whole, the borax treated samples were preferred in five cases and the untreated samples were preferred only twice. Some small plots were treated with the equivalent of 20, 40 and 60 lb. of borax per acre. Tea from these plots was manufactured in the miniature factory. The 40 and 60 lb. borax/acre teas were definitely marked down in comparison with that from the 20 lb. and the no borax plots.

This experiment like the acetic acid one reported above requires further investigation and the method for the present remains an intriguing possibility.

(iii) FERMENTATION TESTING

In the Second Annual Report (1959/60) of the Cambridge biochemical investigation, Dr. Bendall described a method for the quantitative measurement of fermentation. A number of fully turgid tea shoots are weighed and ground up with a known weight of fine pure sand. Complete disruption of all cell tissues results and fermentation is very rapid. At the end of a standard period of one hour the tea is infused with a known volume of boiling water which is kept boiling for ten minutes. After filtration a clear tea liquor results and its total colour, the colour of the ethyl acetate soluble fraction and that of the residual water soluble fraction is measured by an electrical colorimeter. From these measurements the concentration of theaflavins and thearubigins in the liquor can be assessed and this can be taken as an index of fermentation activity and also as an indication of quality potential.

The method is relatively rapid and is certainly quicker than miniature manufacture and the subsequent assessment of the resulting made tea by tasting or by chemical methods. It also requires less leaf material, four shoots being usually sufficient for a test. It may also be considered to be more standard, eliminating variations in technique which may occur in the miniature manufacturing process. Manufacture and the report of a qualified tea taster remain however the final test of any tea which may have been screened and selected by other methods.

The sand grinding and colorimetric method described above will be of great help in the plant breeding work, allowing a large number of bushes to be tested reasonably quickly and more accurately than by the chloroform method. It also enables fermentation ability to be put on a quantitative basis thus allowing comparisons between samples and bushes to be made with more certainty.

Since May, 1960, the method has been used to test a range of tea bushes. Results so far confirm quantitatively, previous opinions as to good and poor bushes.

The chloroform test has been used extensively during the year as a preliminary test for the fermentation ability of individual tea bushes. Whilst some anomalous results have been recorded, the test has proved itself to be on the whole a reliable guide to the better bushes and as such is of great value.

Horticulturist's Report

INTRODUCTION

As predicted in last year's Report, more attention has been given this year to the establishment of rooted cuttings in the field. The results so far are encouraging. The cutting experiments planted during the year will not be finalized at 30 weeks but will be carried through to the establishment of the cuttings in the field as 30-month stumps. This year large numbers of selections have been made by the Plant Breeder and many of these have been propagated under commercial rather than experimental conditions.

Attention has been given to graftage but results so far have been negative. Towards the close of the season an experiment was begun and is designed to examine the effects of stocks and time of grafting on success.

One of the most important developments during the year has been the big increase in the number of estates showing practical interest in vegetative propagation for estate use.

It has been difficult to balance the need for advisory work against the demands of experimental work and the routine management of Swazi.

SHADE AND WATERING EFFECTS ON THE SURVIVAL OF CUTTINGS

During May, 1960, two factorial experiments were planted at Swazi and Cholo and compare the effects of the following treatments on the survival and growth of single node cuttings.

Water was applied at daily, two and three daily intervals. By measuring through a water meter on the hose pipe, three levels of water were applied for each six day period after the start of the experiment. These were 0.6, 1.2 or 1.8 inches and throughout rainfall, which is usually low in the dry season, was ignored. Plots were surrounded by honeycomb brick walls and shaded with one, two or three bamboo lath shades. Incident light measurements using a Western exposure meter indicated that the shade treatments reduced the intensity of full light by 84, 98 and 99.5 per cent. respectively. These are indications only. The fourth group of treatments included three clones.

At thirty weeks after planting, records were taken of the surviving cuttings, those having produced a shoot with not less than 2 open leaflets and an average rooting index was calculated for each plot. Root growth was awarded marks from a value of eight for the maximum growth down to a minimum of 1 mark for live cuttings but with no visible roots. Marks were averaged for plots. Results according to these groups of observations are given in table 20 below and transformation of skew data was undertaken as necessary before statistical analysis.

Watering frequency had no significant effect on any factor measured at either station. At Swazi a total of 0.6 inches of water at 6 day periods was found to significantly reduce the numbers of surviving plants and root development. At Cholo the highest quantity significantly reduced the number of plants with shoots but had no significant effect on survival or root development.

At Swazi, the use of three laths significantly reduced the numbers of survivors below these obtained under one or two laths. Increasing shade density significantly reduced the value of all other factors at both stations.

Clones significantly interacted with water frequency and shade for some factors and this supports the possibility that it may be necessary to modify average methods if these fail with otherwise desirable and valuable clones.

The practical recommendations following from this and other experiments are to water twice per week through two lath shades, reduced to one after six weeks (see below) at the rate of 2 gallons per square yard.

SHADE EXPERIMENT

The experiment described under this heading in the 1959/60 Report was repeated at Swazi and Cholo. This season sufficient material was available to enable the same clones to be used at both stations.

The shade was of bamboo laths on honeycomb brick walls; the rooting medium was ordinary nursery soil and watering was adjusted to keep the soil moist. Single internodal cuttings of 3 clones were planted at both stations during June, 1960. The shade treatments were manipulated at 6 weekly periods as described in table 21. Clones were placed in sub-plots each having 30 cuttings spaced at 3 inches $\times$ 4 inches.

TABLE 20

The effect of treatments on three measurements, at Cholo and Swazi at 30 weeks after planting the cuttings
(a) SWAZI

	Water frequency			Water quantity per 6 day periods			Shade: number of laths			Clone		
	Daily	Alternate days	Every 3 days	0.6"	1.2"	1.8"	1	2	3	SW1	SW6	B10
Per cent. Survival	32.3	32.6	26.8	26.6	34.8	30.3	33.6	33.8	24.3	27.1	30.6	34.0
Per cent. Shooting	18.5	17.2	14.2	14.4	18.8	16.7	27.5	15.8	6.6	13.5	15.4	21.0
Root Index (plot mean)	69.6	71.8	57.7	53.4	75.4	70.3	88.9	66.4	43.8	53.3	68.0	77.8

(b) CHOLO

	50.3	48.7	50.7	52.1	50.0	47.6	61.0	49.5	39.2	43.7	48.7	57.3
Per cent. Survival												
Per cent. Shooting	21.2	24.5	24.3	26.5	24.1	19.4	43.7	18.2	8.1	12.9	21.0	36.1
Root Index (plot mean)	94.0	91.6	92.7	98.3	93.7	86.3	126.6	88.4	63.3	69.4	96.1	112.8

C.V. % Percentages.

Per cent. Survival, Swazi 44, Cholo 19.

Per cent. Shooting (transformed), Swazi 28, Cholo 21.

Root index, transformed, at Swazi 28, Cholo 29.

TABLE 21

Shade treatments in layers of bamboo laths from the time of planting the cuttings

<i>Treatment</i>	1st 6 weeks	2nd 6 weeks	After 12 weeks	<i>Code</i>
1	3	3	3	3+3+3
2	3	2	2	3+2+2
3	3	2	1	3+2+1
4	2	2	1	2+2+1
5	2	1	1	2+1+1
6	1	1	1	1+1+1

The results at 30 weeks are expressed as percentage survivors; those with shoots and as plot mean rooting index calculated as described in the previous experiment, are given in table 22. Data was transformed as necessary.

TABLE 22

The effect of differing shade regimes at Swazi and Cholo on various factors

(a) SWAZI

<i>Factor</i>	<i>Shade treatment, coded</i>						<i>C.V. %</i>
	3+3+3	3+2+2	3+2+1	2+2+1	2+1+1	1+1+1	
Per cent. Survival ..	40.0	45.9	41.9	44.8	39.6	59.6	15
Per cent. Shooters ..	22.6	28.5	30.7	40.0	28.5	52.5	19
Rooting index ..	110	151	142	165	149	225	10 (Trsf.)

(b) CHOLO

<i>Factor</i>	<i>Shade treatment, coded</i>						<i>C.V. %</i>
	3+3+3	3+2+2	3+2+1	2+2+1	2+1+1	1+1+1	
Per cent. Survival ..	13.6	65.1	56.1	60.7	52.2	56.6	11
Per cent. Shooters ..	14.1	30.3	34.4	39.2	35.1	37.0	18
Rooting index ..	178	209	198	182	205	204	4

There were no significant interactions between shade treatment and clone for any measured factor.

There were no significant differences in survival at either station. Significant differences on shoot production were recorded and other than the anomalous reading under 2+1+1 at Swazi the trend is for heavier shade to reduce shoot production. Root production is significantly reduced by increasing shade intensity at Swazi but the differences at Cholo are not significant.

Single lath shades at both stations and for all factors are the best on average. The slight preference for a single lath regime this season as opposed to two reduced after six weeks to one, for the previous season, is possibly connected with a lower sunshine total during the three cool months following planting. In 1959 this period averaged 7.4 hours sunshine per day against 6.6 in 1960.

On balance the practical advice offered is not changed, that is, to shade with two laths reduced after six weeks to one lath.

TABLE 23
The effect of four soils on rooting index

Station	Soil type	Mlanje Red		Mlanje Black		Cholo Red		Cholo Black		L.S.D.	
		L7	SW4	L7	SW4	L7	SW4	L7	SW4	P=0.05	P=0.01
Swazi	Clone										
	Root Indices for clones ..	180	278	47	107	34	78	34	60	—	—
Cholo	Totals for soils ..	458		154		112		94		200	302
	Root Indices for clones ..	236	286	184	151	160	84	162	129	—	—
Both	Totals for soils ..	522		335		244		291		154	234
	Mean for soils ..	490		245		178		193		—	—

C.V. Swazi=28% C.V. Cholo=13%

THE EFFECT OF FOUR SOILS TYPES ON THE ROOTING OF CUTTINGS

In an attempt to understand one possible cause of differing experimental results between the Mlanje and Cholo Stations, two Mlanje soils were taken to Cholo and *vice versa*. From each District a red and a black soil were selected. The soils were put in pits over good artificial drainage and the resulting beds were surrounded by honey-comb brick walls which supported a double bamboo lath shade for the first six weeks and thereafter a single shade. Two clones were used, one L7, of the broad leaved Betjan type and the other SW4 of narrower leaved Indian Hybrid type. Single node type cuttings were planted during May, 1960, and watering was approximately twice weekly and enough to keep the soil moist. The results at 30 weeks expressed as rooting indices are given in table 23.

At both stations Mlanje red soil gave significantly better results than the other soil types. There were no other significant differences.

THE EFFECT OF ROOTING COMPOUNDS ON THE ROOTING OF TEA CUTTINGS

Plots of twenty-four single internodal cuttings from each of three clones were each treated with one of four rooting compounds and compared with a control treated with water only. Otherwise the cuttings were grown similarly under a bamboo lath shade and watered twice a week. Cuttings were planted at 3 inch $\times$ 4 inch spacing and transplanted to a high shade nursery at 30 weeks.

The rooting compounds were:

1. Chloromone, at full strength—a 15 seconds dip. Chloromone is described by the makers as a mixture of auxins A and B.
2. Planofix, a 15 seconds dip at a dilution equaling 100 p.p.m. NAA.
3. Seradix B3, a basal dip in the powder and excess removed by a gentle tap. Seradix is said to contain Indole Butyric salts.
4. Rootone 101, a basal dip in the powder as above. Rootone 101 contains 2-4-5T.
5. Control, a 15 seconds dip in water.

Stems were not moistened prior to dipping into the powders. Tables 24 and 25 give survival and rooting index for each treatment at 30 months after planting.

TABLE 24
Survival percentage at 30 weeks of 3 clones treated with rooting compounds

Clone	MFS 67	MFS 120	MFS 135	Mean for compound
No treatment	50.4	21.0	16.8	29.4
Chloromone	58.8	58.8	33.6	50.4
Planofix	63.0	46.2	12.6	40.3
Seradix	67.2	29.4	16.8	37.8
Rootone 101	58.8	54.6	37.8	50.4

TABLE 25
Rooting index at 30 weeks of 3 clones treated with rooting compounds

<i>Clone</i>	<i>MFS 67</i>	<i>MFS 120</i>	<i>MFS 135</i>	<i>Mean for compound</i>
1 Control	22	19	26	22
2 Chloromone	87	89	49	74
3 Planofix	68	70	18	52
4 Seradix	63	46	13	41
5 Rootone 101	65	86	32	61
Mean for clones	61	62	26	—

It would appear that rooting compounds have aided rooting, especially Chloromone and Rootone 101. The results are more pronounced for root development than for survival.

Investigations into the effect of rooting compounds on the rooting of tea cuttings have been carried out on several tea research stations but the published results have been conflicting. Chloromone and Rootone have been included in a further trial during 1961 and until these results are available the above should not be over-emphasized even though the benefits appear encouraging.

THE EFFECT OF GIBBERRELIC ACID ON THE ROOTING OF CUTTINGS

Twenty-four internodal cuttings of each of 4 clones were treated with Gibberrellic acid and planted under double bamboo lath shades during June, 1960.

The Gibberrellic acid in aqueous solution, was at strengths of 10 and 20 p.p.m. and the bases of the cuttings were dipped into the solutions for 10 seconds. The controls were dipped in water.

The cuttings were dug up for transplanting in mid December and rooting indices calculated.

TABLE 26
Rooting indices for cuttings treated with Gibberrellic acid

<i>Clone</i>	<i>Gib. Acid p.p.m.</i>			<i>Mean for Clone</i>
	0	10	20	
MFS 89	28	18	27	24
MFS 116	21	32	32	28
MFS 127	100	96	46	81
MFS 134	116	97	102	105
Mean for G.A.	66	61	52	—

The indications are that Gibberrellic acid does not assist the rooting of tea cuttings. With MFS 127 it would appear to definitely depress rooting.

INVESTIGATION INTO THE CHECK TO GROWTH CAUSED BY TRANSPLANTING

The investigation into the check to growth caused by transplanting cuttings from striking to nursery beds will not be completed until December, 1962, when stump diameters will be measured. Interim indications are that a considerable check is caused. Planters who have mastered V.P. techniques and who are dealing with clones of known rooting ability are advised to plant the cuttings directly into the permanent nursery site at 6" x 6" under normal lath shades which at 6 months can be replaced by a conventional high nursery shade. Thus the cuttings are not disturbed.

An experiment using this method and investigating the effect of fertilizers on stump diameter at 30 months has been laid down at Swazi.

THE ESTABLISHMENT OF TEA IN THE FIELD FROM CUTTINGS

As mentioned in the introduction to this report it has been possible to give more attention to the problem of field establishment of tea from cuttings, and three lines of approach are being investigated:

- (a) Cuttings transplanted to the field as 6-month-old unpruned plants.
- (b) Stumped cuttings transplanted as 30-month stumps.
- (c) Polythene tube plants—as (a) but cuttings grown in polythene tubes.

As recorded in the 1959/60 Report it seems only possible to establish 6-month-old cuttings in the field if water and shade are available. At Cholo the 6-month cuttings planted in March, 1959, are growing well. These were shaded and watered during the 1959 dry season; at the break of the 1960 rains the shade was removed and used as a mulch. The plants were not watered during 1960 and were only watered to produce cutting material during 1961. Root washing in mid-1961 revealed that their roots have penetrated down to about two feet which is less than expected from seedling stumps. They are thus probably susceptible to severe drought but should rainfall be normal during the next few years it is felt that they will continue to grow well.

The plants could have been given light plucking had it been desired, whereas had they been treated as stumps they would only have been planted out in the field in December, 1960.

A few 6-month-old cuttings were transplanted and covered with plastic wigwam type shades during this year and after some 3 months were left unshaded, but growth was poor.

Transplanting 3-month-old cuttings as stumps parallels the conventional method used with seedlings and nearly 4,000 stumped cuttings were planted during the past rains at the Mimosa and Cholo Stations. The stem diameter of each stump, measured at 4" above soil level, was recorded immediately after planting. Table 27 gives the percentages of stumped cuttings surviving at 6 months against stump diameter measured in 1/16 inch steps.

TABLE 27
The percentage survival of stumped cuttings against stem diameter

	Station	Diameter in $\frac{1}{16}$ " steps of stem at 4" above soil level											
		2 or less	3	4	5	6	7	8	9	10	11	12	13 or more
Per cent. Survival	Mimosa ..	0	24	43	55	60	75	94	91	91	87	97	100
	Cholo ..	13	38	46	54	69	63	78	78	84	80	92	92
	MEAN ..	6	30	44	54	64	74	81	86	88	84	94	97

Although these are interim data referring to survival at only six months after transplanting to the field, they indicate strongly that survival potential can be linked with stump diameter as is the case for seedling stumps.

1m seedlings a survival rate of not less than 90 per cent. can be expected by using stumps of 7/16 inches diameter or more (*see* Annual Report for 1959/60). In the present series with cutting stumps, survival from those at 7/16 inches or greater is so far, 83 per cent. at Mimosa and 75 at Cholo. A more complete comparison between the survival of cutting and seedling stumps will be available at the end of 1961.

As expected, observations show that some clones are more easily established in the field than others but it is not necessarily those that rooted easily in the nursery that establish well after transplanting or *vice versa*. One clone, now rejected because of poor rooting in the cutting beds, has over 95 per cent. survival of such few stumps as it produced and these have yielded growth which compares favourably with adjacent seedling stumps of the same age.

Cutting and seedling stumps for comparison, were planted in adjacent plots over a ten week period, beginning on 1st December, 1960, at Mimosa and 20th December at Cholo. Recordings at six months show very slight differences between late and early planting as regards survival but growth is most definitely greater with the earlier planting dates.

The establishment of cuttings in polythene tubes or of transplanting rooted cuttings into polythene tubes in the hope that these would later be transferred to the field, has been very disappointing, and the matter will receive considerable attention during 1961/62. It is possible that soil compaction and temperature fluctuations may be the cause of poor results.

Cuttings appear to root readily in polythene tubes but thereafter die back. The Plant Pathologist was unable to find any pathogen which might have caused death.

MIST PROPAGATION UNIT

During the year the mist unit has changed from an experimental to a production unit. This does not mean that all problems are solved but simply that enough is now known to enable it to be used effectively. A summary is given of the results of the past three years work with comments.

(a) MEDIUM: For tea an acid medium is necessary and under mist, free drainage is essential. Bearing in mind the economic aspect, a mixture of a red acidic loam soil and river sand, in equal parts, is satisfactory providing the pH of the mixture is in the region of 5.0. Free drainage of the medium has been achieved by using boxes or benches with plastic mosquito gauze and XPM bases.

(b) MIST: Under local conditions the use of continuous, 6 a.m. to 6 p.m. mist, or intermittent mist controlled by a hydrostat (or electronic leaf), appears to give equally good results. There was no appreciable cooling of the medium caused by the continuous mist, this may be due to the fact that the water supply is relatively warm coming from a nearby stream through water pipes on the soil surface or only shallowly buried. When the control apparatus is working well, then the saving of water by the intermittent mist is of great importance. Recordings indicate that continuous mist uses about ten times as much water as the intermittent.

(c) LIGHT: Shade is considered important but whereas about 10 per cent. of full light appears the best for out-door cuttings, 25 per cent. full light seems quite suitable under mist and this increase will presumably help photosynthesis.

(d) PLANT MATERIAL: So far, only single internodal cuttings from material of about one year or less have been used and these seem quite suitable. The important aspect of the unit is that of the 25 clones placed under mist none has failed to root though some are stronger rooters than others. It was with the object of propagating reluctant rooting clones for the Plant Breeder, that the unit was initially set up and to date the indications are that it will fulfil this function.

(e) **SPEED OF ROOTING AND SEASON:** As far as can be judged at present, propagation under mist can go on successfully all the year round provided that good cutting material is available, and that the rooted cuttings can be grown on after leaving the mist house. In consideration of this it should be noted that cuttings are usually rooted in about 10 weeks. Hardening off then begins, requiring about another 4 weeks before leaving the mist house. Thus three batches of rooted cuttings per year can be expected from the unit.

(f) **GROWTH AND NUTRIENT ADDITIONS:** The development of the axillary bud of the cutting is often much quicker under mist than out of doors, but this does not seem detrimental. As may be expected there is considerable variation between clones in the rate of new growth. New growth under mist (and polythene cloches) seems to be very pale green in colour and attempts were made to cure this by using sulphate of ammonia and Sea Magic (a proprietary nutrient solution) injected into the mist, or by sulphate of ammonia and a granular fertilizer (4 :16 :15) applied to the surface of the medium. (The injection of nutrients into the mist cause the hydrostat to fail. Thus whenever nutrients were injected continuous mist was used.) None of these treatments affected the appearance of the new growth and ultimately the plants develop normally. Sulphate of ammonia possibly increases root growth, especially so when injected into the mist.

(g) **TREATMENT AFTER ROOTING:** Is not as far advanced as the rooting methods, but is under investigation. After rooting at 10 weeks, the cuttings have been gradually hardened by reducing the amount of mist and increasing the amount of air circulation in the green house. Mist reduction is effected by turning the mist off during the night and gradually reducing the day time hours of mist and by moving the hydrostat near the atomiser so that the actual bursts of mist are of shorter duration. This method proceeds gradually over about 4 weeks after which no mist is required, except on very hot and dry days. At this stage it was hoped to move the plants to a conventional nursery, some in polythene tubes and others in beds. On one occasion this proceeded quite well but on another many plants were lost. This was due to poor rooting caused by troubles with the equipment whilst the cuttings were under the mist and by soil troubles in the tubes. Of the better batch of plants planted into polythene tubes, half were each given one seventh of an ounce of a compound granular fertilizer 4 :16 :15 every month, but this led to several deaths probably due to salt concentration in such a small volume of soil. Plants placed into beds instead of tubes definitely benefited by the equivalent application of the same fertilizer.

A further batch of rooted cuttings has been planted into 8 inches $\times$ 15 inches polythene tubes, and every effort has been made to avoid soil compaction, temperature fluctuation (by burying the tubes) and capping (by using a mulch). Sulphate of ammonia has been applied at the rate of 1 ounce to 36 tubes. Polythene cloches have been used to help the plants to overcome the physical effects of transplanting and of environmental changes. It is hoped to remove the cloches a month or so after transplanting, and to use the plants at nine months old for establishing a clonal seed garden in a site where water and shade are available.

(h) **CONCLUSIONS:** Overall, the mist unit has proved successful in rooting tea cuttings of all clones tried but problems still remain with the subsequent stages.

POLYTHENE CLOCHES

During the past season, experience has been gained in the use of polythene tents or cloches as an aid to vegetative propagation. The main effect of these cloches is to provide a stable humid environment for the cuttings, eliminating to a large extent the harmful effects of great and rapid changes in humidity and avoiding mechanical injury due to wind or watering.

These cloches are constructed from polythene sheeting draped over frames of bamboo or wire which are about 24 inches above the ground level at their highest mid point. The edges of the sheets are dug into the earth and the cloches are thus sealed.

Such cloches have been used in two main trials.

Single internode cuttings of Indian Hybrid tea placed in polythene tubes during August, 1960, were arranged into three groups of 100 each. Each group was placed in a polythene cloche sited under natural tree shade.

The first of these was opened, watered and weeded one month after planting, the second at two months and the third at three and a half months. Using survival counts and the usual assessment of new growth there seemed to be no difference between the three treatments or the two clones which were used. After hardening off during the early rains it was desired to reduce the amount of shade but because the cloches were sited under natural forest shade this meant moving the plants to a conventional nursery. The use of natural shade appeared at first sight to be economically desirable but its lack of flexibility as found out later, renders it impracticable.

Deaths which occurred might have been due to soil compaction within the tubes, to adverse temperature fluctuations in the nursery or to soil capping on the surface of the tubes. However deaths later occurred in similar plants left at the cloche site and thus the change from natural to artificial shade is not considered to be a main factor.

The second trial planted in late March used 50 cuttings each of 16 Betjan type clones planted into conventional beds which were then covered with polythene cloches. The cloches were then shaded by the conventional 6 feet high nursery shade. Weeding and watering took place once every six weeks. By July the plants were hardened off to enable the polythene to be removed.

Of the sixteen clones used only four had less than 80 per cent. survival at the end of the hardening-off period.

A COMPARISON OF CLOCHE AND MIST PROPAGATION

An equal number of cuttings from the 16 clones used in the above trial were also propagated under intermittent mist in the glass house and a comparison of the results of two methods is given in table 28. All data were taken at four months after planting

TABLE 28
A comparison of results of cuttings grown under mist and cloches

	Glass house with mist	Cloche
Per cent. Survivors	99	80
Per cent. with shoots over 1" long	30	38
No. of new leaves produced	369	609

These results indicate that although survival is lower in the cloches subsequent growth is better.

The use of cloches is receiving further attention and a new trial compares an outdoor cloche fitted with mist and shaded with bamboo laths.

Previous investigations have showed that new shoots produced about six months after pruning the parent bush make very suitable material for cuttings. However difficulties have been found with striking cuttings under lath shades during the rains and thus it has only been feasible to use one crop of cuttings during the dry season of each year. The polythene cloches, by protecting the cuttings against the ill effects of heavy rain, offer a potential method of taking a second crop each year and thus speeding up the work of plant improvement. It may also be possible to produce plants under polythene from material which would otherwise be discarded.

Experiments with *Eucalyptus saligna*

THREE CUBED FACTORIAL, N, P₂O₅, AND DIELDRIN ON YOUNG EUCALYPTUS TREES

This experiment entered its second year and the results expressed as tree mean diameter at breast height (D.B.H.), are given in table 29.

TABLE 29

The effects of treatments on mean diameter at breast height of *Eucalyptus saligna* trees at 19 months after planting

Treatment	S. Ammonia			Single super-phosphate			Dieldrin			L.S.D.	
Nutrient lb./acre	N			P ₂ O ₅			a.i.			P=	P=
	0	30	60	0	14	28	0	1.5	3	0.05	0.01
Mean DBH in ins. . .	1.76	2.06	2.13	1.89	1.91	2.14	1.83	2.14	1.98	0.31	0.42

C.V. % = 22.5

The highest rate of sulphate of ammonia significantly increased mean diameter over those trees receiving no sulphate of ammonia. Single superphosphate caused no significant differences at 19 months although it did have significant beneficial effects twelve months earlier.

The low rate of Dieldrin caused a significant increase in mean tree diameter probably by increasing the number of survivors; the high rate was not significantly better than the untreated control.

As mentioned in last year's report there seemed to be correlation between volume of growth and the sulphur content of the fertilizers applied. The regression of diameters on the sulphur content of the 9 possible combinations of N and P₂O₅ is $D = 3.0195, S + 0.57$ where D is the diameter and S = lb. of sulphur per acre. This regression accounts for 52 per cent. of the sums of squares of the dependent factor and is significant at $P = 0.05$.

THE EFFECT OF SULPHUR AND UREA ON THE GROWTH OF EUCALYPTUS

Following the results of previous experiments an experiment comparing the effects and interplay of nitrogen and sulphur was started. These were sited at Swazi Tea Research Station in the Mlanje District and, by the kindness of Forestry Department, on Amalika Forestry Station in the Cholo District.

At each station randomized block designs were used. Seedlings trees were planted in January and the treatments applied in early March.

Treatments were:

S0=no sulphur

S1=30 lb./acre sulphur (S.) as flowers of sulphur

S2=60 lb./acre sulphur (S.) as flowers of sulphur

N0=no nitrogen

N1=30 lb./acre nitrogen (N.) as urea

N2=60 lb./acre nitrogen (N.) as urea

In October the height of the trees was measured. Tables 30 and 31 give the results expressed as feet of growth per acre for both stations.

TABLE 30
The effect of sulphur and urea on the growth of *Eucalyptus saligna*
at Swazi

				Nitrogen			Mean for S.
				0	30	60	
Sulphur	0			9,378	9,599	9,855	9,611
	30			14,325	11,360	11,360	12,312
	60			10,792	10,735	13,291	11,606
Mean for N.				11,498	10,565	11,466	11,176

C.V.=16%

Differences are not significant, probably due to the anomalous S1 N0 result. Measurements were rechecked and there is no explanation offered for this result from this treatment combination.

TABLE 31
The effect of sulphur and urea on the growth of *Eucalyptus* at Amalika

				Nitrogen			Mean for S.	L.S.D. Main treatments P=		
				0	30	60				
Sulphur	0			7,811	8,588	7,815	8,071	0.05	0.01	0.001
	30			7,680	12,027	13,485	11,064			
	60			8,012	11,997	13,545	11,185	3,132	4,245	5,683
Mean for N.				7,834	10,871	11,615	10,107	—	—	—

C.V.=12%

Increasing rates of both nutrients have caused significant linear increases in growth.

CONCLUSIONS

The indication from these and past seasons' experiments are that *Eucalyptus* seedlings will benefit from the application of sulphur bearing fertilizers applied shortly after transplanting. The effects are not so pronounced a year later. In general, this picture closely parallels that for transplanted tea.

THE ESTABLISHMENT OF EUCALYPTUS IN THE FIELD

At Swazi Tea Research Station, *Eucalyptus* seed sown in nursery beds during August, 1960, was transplanted the following November into:

- (a) 6" polythene tubes filled with soil,
- (b) Beds of soil: compost: sand (15 : 6 : 6) and spaced therein at 6 inches by 6 inches,
- (c) Some were left undisturbed, in the original seed beds.

In mid February, 1961, these were moved to the field site:

- (i) in the polythene pots
- (ii) from the soil: compost: sand beds, by using a Hershall transplanter.
- (iii) From the original seed beds after digging out with a hoe.

In mid April the survival counts were taken and are given in table 32.

TABLE 32
The effect of planting method on the survival of blue gums

<i>Polythene Pots</i>	<i>Hershall</i>	<i>Hoe</i>
92	66	35

The benefit of polythene pots on the establishment of gums is clearly demonstrated, and the usefulness of the Hershall planter should pots not be available is also shown. In essence these data indicate that the less disturbance that is given to the root systems during transplanting the better is the survival thereafter. It is interesting to note that the traditional method of digging out seedlings with a hoe is rapidly giving way to the use of polythene potted seedlings throughout the industry.

Extract from the Annual Report of Dr. C. V. Cutting, Senior Agricultural Chemist, Department of Agriculture

ESTATE DEVELOPMENT

One Mlanje company wishing to establish a well-isolated seed garden enquired if another of their estates in the Blantyre area could be used for this purpose. As was expected in this locality, with rainfall lower than in the usual tea areas, the pH (6.0) was marginal for tea. The soils are less well developed to depth, being compacted with blocky structure, with frequent quantities of stone and quartz. The intention was to plant near a stream for ease of irrigation, but this would probably have led to poor root development. This area was therefore not considered suitable.

Tea seedlings showing leaf curl and distortion were examined on a Cholo estate, as the irrigation water was suspected. As previous seedling dieback in this area had been attributed to soils of higher pH, this factor was also checked. Both soils and water were found to be satisfactory, the trouble being finally attributed to thrips. Advice also continued to be given on proposed sites for nurseries, and it is encouraging to see estates taking increased interest in their soils, and digging pits for their own examination of possible areas.

A report was requested on a developing tea estate in the Northern Province. A main point in assessing soils for tea growing is their physical nature as regards water retention in the dry season. Some of the soils concerned were of low water holding capacity. It therefore appeared that full use should be made of the better, heavier soils, with the possible irrigation of these to give maximum yields, as water was plentiful.

Advice was also given regarding the suitability, for tea growing, of certain parts of the north of Northern Rhodesia. Broadly, the soils were rather less acid than desirable for tea, and rather light in texture. The most promising areas were certain soils in the Mpika and Kasama districts, but more detailed surveys and information would be required for final decisions.

CHOLO TEA STATION—RUN-OFF EXPERIMENTS

On the basis of the original soil survey of the Cholo Tea Station (*see* 1957/8 Report), a site was selected for the run-off experiments described elsewhere in this report. This covered both main soil series, one experiment being located on each. The proposed plots were then examined for uniformity, 36 borings to six feet being made. The Step Terrace experiment was sited on deep loam derived from basic rock, although occasionally some quartz occurred in the profile. The clay content at two feet varied between 44 per cent. and 54 per cent., and this degree of variation was

considered satisfactory, particularly as the two experimental plots were parallel, running down the hills. Any differences therefore tended to run across the plots, and therefore were common to both. The broad-based bund experiment occupied the quartz containing soils derived from more acidic rock. The original proposal was to have two strip plots, and the survey was made accordingly. There were two belts containing appreciable amounts of surface stone, and also quartz at three to four feet. These however crossed both plots to give a practical uniformity over each. The soils were rather less heavy throughout, containing 35-45 per cent. clay at two to three feet. Subsequently it was necessary to use this same area as two square plots, but uniformity was maintained as the eastern half of each was similarly affected by surface rock, and quartz in the profile.

SOIL NUTRIENT CHANGES UNDER TEA

Continuing the work described last year in connection with the 10 year old NPK experiment at Swazi Station, the data on soils taken to depth from selected plots is summarized below, for organic matter (O.M.), available phosphate by ammonium fluoride extraction (Pa), and exchangeable potassium (K). The pH figures quoted are for top, and sub soils respectively.

$N_2P_2K_1$ Plot

A. Equidistant from four bushes							B. Midway between bush and A						
Site I			Site II				Site I			Site II			
pH 4.9/5.0			pH 4.7/5.2				pH 4.7/4.8			pH 5.0/5.1			
Depth	OM	Pa	K	OM	Pa	K	OM	Pa	K	OM	Pa	K	
0-6" ..	4.3	110	.36	4.3	106	.11	4.3	101	.24	4.3	66	.11	
6-12" ..	3.2	78	.26	1.8	18	.04	2.0	18	.20	1.6	26	.13	
3' ..	2.2	44	.14	1.2	13	.07	.9	13	.15	1.1	18	.09	
6' ..	.7	13	.04	.7	18	.04	.5	9	.07	1.1	13	.07	
10' ..	1.0	4	.04	1.1	13	.06	.5	4	.07	.5	9	.03	

$N_0P_0K_0$ Plot

A. As A above							B. As A above						
Site I			Site II				Site I			Site II			
pH 5.4/5.4			pH 4.9/5.3				pH 5.1/5.5			pH 5.3/5.3			
Depth													
0-6" ..	3.6	44	.12	3.4	54	.14	4.3	46	.33	3.8	48	.14	
6-12" ..	1.6	31	.06	1.6	25	.10	1.8	22	.09	2.0	26	.07	
3' ..	1.1	18	.05	1.1	18	.05	1.3	15	.07	1.3	18	.03	
6' ..	2.7	13	.05	1.1	13	.03	1.3	18	.08	1.1	13	.02	
10' ..	1.1	13	.19	—	13	.03	1.2	18	.07	—	13	.03	

$N_2P_0K_0$

Position as A above

Site I			Site II			
pH 4.9/4.7			pH 4.5/4.4			
Depth						
0-6" ..	4.1	31	.12	2.9	13	.11
6-12" ..	2.5	9	.04	1.6	9	.03
3' ..	.9	9	.02	—	4	.03
6" ..	.7	4	.03	.7	4	.03
10' ..	.7	Nil	.03	.3	4	—

$N_0P_2K_0$

Position as A above

Site I			Site II			
pH 5.1/5.4			pH 5.3/5.4			
Depth						
0-6" ..	4.1	115	.32	3.9	115	.32
6-12" ..	2.5	9	.04	1.6	9	.03
3' ..	.9	9	.02	—	4	.03
6" ..	.7	4	.03	.7	4	.03
10' ..	.7	Nil	.03	.3	4	—

Adjoining Non-Cultivated Area

Under forest					Under grass by side of tea				
pH 5.4/5.3					pH 5.3/5.4				
Depth									
0-6" ..	3.6	26	.11		4.1	18	.15		
6-12" ..	2.1	13	.04		2.5	13	.11		
3' ..	1.8	4	.07		2.3	4	.07		
6' ..	.9	4	.06		1.0	9	.05		
10' ..	.7	4	.03		1.4	4	.09		

Although the phosphate applications have increased the available phosphate in the upper soils of the profile, the effect is less at depth. The accumulation of leaf fall and prunings on the control plots, also gives rise to phosphate accumulation in the top soils. It is interesting to note that this build up is greater than that obtained under nearby semi-forest less than 100 yards away. The absence of accumulation under the adjoining grass area is more understandable, particularly as the organic matter content is lower. One assumes that the greater growth and volume of the forest trees, in relation to leaf fall when compared with the smaller tea bushes, leads to a greater utilization of phosphate. However application of phosphate, without nitrogen does give an increase of available phosphate, and it is noteworthy that where nitrogen is applied without phosphate, some depletion of phosphate in the upper soils and possibly throughout the profile occurs. This would seem to support the present recommendation that phosphate should be applied every two or three years, although so far no responses in yield to phosphate in fertilizer experiments have been shown. An examination of other plots is desirable to obtain additional data in this respect, but without further staff, this has not been possible. It should be noted however, that even at a level of only 5 p.p.m. throughout the profile, this means that to a depth of ten feet the tea bush has access to the equivalent of 1,300 lb. of single supers per acre. The figures for phosphate reserves (extracted with N/10 hydrochloric acid) follow very much the pattern of changes shown by those for available supplies of this nutrient. They vary from 110–160 p.p.m. in the top soils of the $N_2P_2K_2$ plots, becoming 13–40 at three feet. Where no phosphate or nitrogen has been applied the corresponding figures are 90–120, and 45–60. Again it may be important that where high dressings of nitrogen have been applied without phosphate, the reserves are 40–90 in the top soil and 15–20 at three feet. The use of phosphatic fertilizers without nitrogen, increase the phosphate reserves when compared with the N_2P_0 plot, viz. 170 and 90 against 95 and 70 respectively in top and sub soils.

ARBORICIDE TRIALS

The investigations outlined in last year's report have been pursued but unfortunately, due to other duties and also to theft of trees it was not possible to complete the full programme planned.

In the trial with indigenous species, the carbohydrate content of representative roots 18–24 months after the start of the observations, is shown in table 1 below, which also summarizes the trends noted during the trials. Starch (St) and sugar (Su) figures are given for each tree.

TABLE 1
Content of carbohydrates in roots of indigenous trees

	<i>Afromosia</i>	<i>Cussonia</i>	<i>Erythrina</i>	<i>Isobertinia</i>	<i>Parinari</i>	<i>Pterocarpus</i>	<i>Uapaca</i>
Control							
Starch	18.2	3.9	19.3	12.0	6.1	17.1	12.6
Sugar	4.8	5.9	6.2	6.2	3.1	4.3	4.1
Ringbark							
Starch	2.0	4.0	1.6	4.4	1.4	—	2.4
Sugar	1.9	0.7	0.4	4.9	2.7	—	1.6
D42i 5%							
Starch	2.1	3.6	3.1	1.5	3.2	—	1.6
Sugar	1.9	1.1	0.8	0.7	1.8	—	0.8
245T 5%							
Starch	—	3.0	3.1	2.3	1.3	0.8	1.5
Sugar	—	2.0	0.8	5.7	1.6	0.2	1.9
Additional data on control trees							
Maximum Starch ..	23	4	21	22	6	19	13
Maximum Sugars ..	6	7	6	5	4	5	4
Minimum Starch ..	6	2	5	5	3	6	4
Minimum Sugars ..	1	4	1	2	3	3	1
Period when starch is Min. } .. Nov.—	little		Oct.	Dec.—	Dec.—	Dec.—	Mar.—
} .. Feb.	change			March	March	March	May

It is seen that the trees can be divided into two groups according to average starch content. *Afrormosia*, *Erythrina*, *Isobertlinia*, and *Pterocarpus* have high starch contents (approximately 20 per cent. at their maximum), whereas *Cussonia* and *Parinari* have a much lower content (4-6 per cent.), and *Uapaca* is intermediate having a maximum of 13 per cent. The minimum of all trees was rather similar, and showed little variation being in the range of 2-6 per cent. The time of the year for minimum starch content is also given, although confirmatory data is required. *Cussonia*, alone, showed little seasonal variation. This tree was also different from the other six species, in so far as the content of sugars was higher than that of starch, throughout the year, in the control trees, but not in those treated. Sugars decreased as starch decreased in *Isobertlinia*, and *Uapaca*, but the reverse applied with *Parinari* and *Pterocarpus*. Variable results were indicated by *Afrormosia* and *Erythrina*.

First indications were that 245T was more efficient on species of high starch content, and which are therefore slower to respond to ringbarking. 24D generally gave better results than 245T on those species with a lower starch content. Ringbarking initially appeared most effective on *Isobertlinia*. However as in most cases, the ringbarked trees finally contain the same, or only slightly more, carbohydrate as those treated with arboricide, i.e. ringbarking has caught up on the initial treatment, it appears that the metabolic loss of arboricides may necessitate repeated applications. In the absence of laboratory techniques for assessing armillaria attack, the criterion for evaluating the arboricides, must be whether they accelerate the depletion of starch to the figure obtained in the ringbarked tree after two years. The only tree in which this applies is *Uapaca*, which, with both 24D and 245T, has a starch content after 18 months treatments, as low as that produced two years after ringbarking. A further secondary observation from the results is that the low starch-containing *Parinari*, appears to reach its lowest level about 6-9 months after any treatment. Again, *Cussonia* is anomalous, and the treatments appear to lead to increased carbohydrate content.

Another interesting observation related particularly to *Afrormosia*, *Erythrina*, *Isobertlinia*, and *Pterocarpus*, is the fact that the treated trees (particularly those ringbarked) show a similar cycle of starch content to the control, i.e. seasonal increased starch contents are indicated, but at a lower level than those in the non-treated trees. This again would suggest that either application was not made at the optimum time or that repeated applications would be advisable.

The figures quoted above refer to dry material, and it should be noted that the moisture contents of roots varied appreciably as would be expected, being up to 70 per cent. in *Erythrina* in the rains. A similar change in moisture content up to a maximum of 60 per cent. was found in samples from the *Grevillea* experiment at Mimosa, the figures for carbohydrate content given below, being on a dry matter basis.

TABLE 2
Carbohydrate content of *Grevillea* roots—treatments applied September, 1960

Treatment	Control	Ringbarked	24D		245T			TBA	
			1 × 6%	2 × 3%	1 × 6%	2 × 3%	3 × 2%	1 × 6%	2 × 3%
Starch %									
October, 1960 ..	11.1	5.2	3.4	3.4	8.0	3.0	3.5	5.2	11.1
January, 1961 ..	11.9	3.4	3.1	3.5	4.3	3.5	3.5	8.0	9.5
Sugars %									
October, 1960 ..	.9	.7	.7	.7	.8	.8	.7	.7	.7
January, 1961 ..	1.5	2.3	2.8	1.5	2.8	1.1	0.2	2.9	.9

The ineffectiveness of TBA is clearly seen, and it appears that the initial advantages shown by 24D and the multiple applications of the lower level of 245T, were lost after a further three months of growth during the rains.

METHOD DEVELOPMENT

In the course of the work outlined above, subsidiary investigations have been made into the starch distribution in the roots when comparing the effects of drilling for samples and excavation of whole roots. Results varied among species and samples, most likely due to variations between trees of the same species. Other workers have reported 20-50 per cent. variation between different trees of the same species, in different years. These points are of particular importance where the extent of the work must necessarily be limited, as occurred in this investigation. However it is considered that the differences are such that general conclusions about trends can be drawn from these results.

To facilitate the chemical work involved, an examination was made of existing methods, utilizing the anthrone reactions. The preliminary extractions were accelerated by replacing the time consuming repeated centrifuging with alcohol and followed by perchloric acid. The 50 mg. samples were refluxed with alcohol for one and a half hours, with occasional crushing of the sample for extraction of sugars. This was followed by digestion with 0.25 N sulphuric acid for the determination of the starch component. Typical comparative data obtained by both methods are shown below:

Species				Tree No.	Alcoholic extract Centrifuging Reflux	Acid extract Perchloric, Sulphuric, centrifuge digestion	
					(micrograms found in aliquot)		
<i>Afromosia</i>	..	..	..	118	55	40	150
<i>Erythrina</i>	..	..	..	47 I	25	21	90
<i>Erythrina</i>	..	..	..	47 II	30	39	102
<i>Isobertinia</i>	..	..	..	59	310	322	210
<i>Uapaca</i>	..	..	..	11	240	250	88
<i>Grevillea</i>	..	..	..	9	35	28	210
							240

TEA FERMENTATION

During the year 15 samples of enzyme concentrate have been prepared, and sent to Cambridge University. Activities varied between 8 and 30 units/gm., although generally the desired level of 20 units was reached. Green leaf despatches, from specified bushes, have also continued. During Dr. Bendall's visit in March/April assistance was given to his investigations both in the laboratory and in manufacturing trials at two factories.

Soil Physicist's Report

by

R. A. Wood, Department of Agriculture

(i) SOIL MOISTURE USE UNDER MATURE UNSHADED TEA, SWAZI

As in previous seasons, readings from gypsum blocks were taken at weekly intervals under pruned and unpruned tea to a depth of 17 feet 6 inches. Changes in available moisture status as indicated by the gypsum blocks were supported by gravimetric soil moisture determinations. These are presented in table 1 as inches of available water found in the profile under the two treatments to a depth of 17 feet 6 inches.

TABLE 1
Changes in available moisture under pruned and unpruned
tea to a depth of 17 feet 6 inches

Date	Inches of available water	
	Pruned	Unpruned
November, 1959	11.42	6.56
January, 1960	22.20	16.76
June, 1960	24.28	19.10
September, 1960	22.60	21.65
November, 1960	8.66	5.92
February, 1961	21.19	22.53
June, 1961	19.84	16.63
September, 1961	18.43	14.57

N.B. Available water held between field capacity and wilting point
in the 17 feet 6 inches profile = 31.32 inches.

The figures clearly show the more rapid drying out that occurs under the unpruned tea during the dry season, pruning having delayed moisture usage.

The overall picture of variation in moisture use occurring since the deeper blocks were installed in 1959, and which is confirmed by the above figures, is presented graphically in fig. 1, each point being the average of six block readings.

Poor dry season rains in 1959 caused drying out under both treatments to occur much earlier than in the 1960 or 1961 dry seasons when rainfall was considerably higher. Consequently the moisture conservation effects due to pruning are not as marked in the two latter seasons. It is interesting to note however that moisture reserves were being tapped at the 15 foot level in both the 1959 and 1960 dry seasons.

(ii) SOIL MOISTURE USE UNDER MATURE UNSHADED TEA, NCHIMA

A replica of the experiment at Swazi was laid out at Nchima in 1960 to study moisture use effects under the lower rainfall conditions of the Cholo area. The block readings followed much the same pattern as those under the pruned and unpruned treatments at Swazi except that drying out in both treatments started earlier and more available water was lost during the 1960 dry season than at Swazi.

(iii) SOIL MOISTURE USE UNDER YOUNG TEA WITH AND WITHOUT INTERPLANTED SHADE TREES, MIMOSA

In May, 1958, gypsum blocks were installed at 1 foot, 5 foot and 10 foot depths in each of the subplots of the shade tree experiment at Mimosa. There are four shade treatments: no shade, *Albizia gummifera*, *Grevillea robusta* and *Glyricidia maculata*. Since then block readings have been taken at weekly intervals and periodically gravimetric soil moisture measurements have been made. Fig. 2 shows available moisture usage from July, 1959, to October, 1961, according to the main shade treatments, each entry on the figure being the average of 16 readings.

Although shade treatments have had significant effects on yields (these appear elsewhere in this report) there would appear to be little to indicate from these graphs that they can clearly be related to differences in soil moisture status between shade treatments. The very rapid drying out of the profiles to depth between September and November, 1960, is associated with a flush of growth which occurred during a rainless period in these hot months, and illustrates very clearly the considerable demands tea is capable of making on available water supplies. This however seems to be more or less independent of the type of shade present.

(iv) WIND BREAK EXPERIMENTS AND SOIL MOISTURE STORAGE, MIMOSA

An experiment was commenced last season to study the effects on yield when tea is sheltered against wind. The following treatments were used; no shelter, netting as a shelter, and netting plus sacking. Because it was suspected that these treatments may affect moisture storage, gypsum blocks were installed under each of them at depths of 1, 4, 7, and 10 feet. Regular readings have been taken and in addition gravimetric moisture determinations made.

Preliminary figures have shown that during the dry season least drying out occurs on the plots with netting plus sacking, followed by those with netting only, while the un-sheltered plots lost most moisture.

Nematode Survey

by

G. C. Martin, Senior Helminthologist, Federal Ministry of Agriculture

SOUTHERN PROVINCE, NYASALAND

During August, 1960, an extensive survey of tea nurseries and gardens in Cholo and Mlanje Districts was made by the Senior Helminthologist, Federal Ministry of Agriculture, Salisbury, Southern Rhodesia. In the course of the survey it became apparent that plant parasitic nematodes were causing considerable damage, particularly in nurseries. Seven estates were visited in Mlanje and eight in Cholo.

In nurseries, plants in patches which were stunted and chlorotic, were dug up and the roots examined for signs of nematode attack. A similar procedure was adopted in tea gardens where unthrifty plants were selected.

NURSERIES

It is apparent from preliminary investigations, that *Meloidogyne* spp. are widely distributed throughout the nurseries of the tea growing area of the Southern Province. On every estate visited, with two exceptions, infected plants were obtained from one or other of the nurseries examined. Infections ranged from localized patches of lightly infected plants to considerable areas of relatively heavily infected seedlings, and in one instance the entire nursery was badly affected. On a number of occasions, roots of healthy large plants were examined and were found to be comparatively free from root-knot nematode infections.

In view of the close association found between the presence of galls and poor growth, it is assumed that moderate to heavy infections with *Meloidogyne* spp. can seriously retard the growth of tea seedlings.

The degree of galling found was never as heavy as is usually associated with marked retardation of growth in such plants as tobacco and tomatoes. Galls on the lateral and feeder roots were small but not infrequently, the upper 4 or 5 inches of the tap root and the stem below soil level, were found to be covered with large "wart like" swellings.

The numbers of living female nematodes and egg masses seen were low in relation to the degree of galling on the roots. Many of the small galls contained dead and discoloured female nematodes and very few egg masses were visible on the outsides of the galls. Living female nematodes and egg masses within the galls were present in the largish "wart like" swellings described above, but again not in the numbers expected. Many of the lateral roots were dead or dying and a certain amount of rot was observed.

It is thought that lateral roots of tea seedlings are readily killed by attacks of *Meloidogyne* spp. and are probably shed. From one nursery only was a "normal" infection observed, such as that obtained on a tomato plant. In this one instance, the lateral roots remained alive and the small galls, which were "soft" and not "woody" contained living female nematodes with well filled egg masses visible on the outsides of the galls.

No evidence of infection was observed on seedlings of three to five months old, planted in the 1960 nurseries. The heaviest infections seen and the greatest damage done were in the 1959 nurseries, on 15-18-month-old plants. Light infections only were recorded from thin spindly plants, which were of average or normal height in the 1957 and 1958 nurseries. In 70 per cent. of the infections recorded, *M. javanica* was the species involved, in the remainder, with the exception of one nursery infested with *M. incognita* var. *acrita*, the species was found to be *M. arenaria*. The descriptions given above of the types of galling and numbers of female nematodes seen, apply generally to all three species of *Meloidogyne* found. In *M. arenaria* infections, male nematodes were present in the "wart like" swellings and in the *M. incognita* var. *acrita* infection, the galls on the lateral roots were larger and "elongate bead like" in appearance with comparatively more female nematodes present.

GARDENS

Tea bushes from tea gardens on eight estates were dug up and the roots were examined for root-knot nematodes. No infection was observed in the field but on return to the laboratory, three bushes were found to be lightly infected with *M. javanica*, in two of these cases no eggs were found. The ages of the infected bushes ranged from 5 to 35 years and eggs were present in the latter instance. The nursery, already mentioned, which was found to be heavily and extensively infected with *M. javanica*, was situated in an old tea garden, the 35-year-old bushes having been grubbed out to make room for the nursery, and is situated immediately adjacent to the garden from which the 35-year-old infected bush was obtained.

Indications are that plant parasitic nematodes, *Meloidogyne* spp. in particular, present problems in tea nurseries but not in gardens.

Only light plant parasitic nematode attack and infestations were found in tea gardens; these coupled with the absence of unthriftiness in young tea bushes in replanted old gardens, indicate that at the moment, nematodes are not a problem of tea gardens.

EASTERN HIGHLANDS AREA, SOUTHERN RHODESIA

A similar survey was carried out over six estates, at twelve nursery sites in the Inyanga and Chipinga areas of Southern Rhodesia. *Meloidogyne* spp. were found infecting all the sites examined: *M. javanica* was present in eight sites and *M. arenaria* in three. Infections ranged from heavy with marked galling, to light root knotting. In three nurseries investigated, the number of nematodes was greatly reduced by preplanting fumigation.

SOIL EXAMINATION

In addition, soil samples were taken from nurseries and gardens from all the estates visited. Numbers of different genera of plant parasitic nematodes were found; the names of these are appended below.

(Positively Identified)

Aphelenchoides sp.

Criconemoides sp.

Ditylenchus sp.

Scutellenema sp.

Trichodorus sp.

Tylenchorhynchus sp.

<i>Helicotylenchus</i> sp.	<i>Tylenchus</i> sp.
<i>Hemicriconemoides</i> sp.	<i>Xiphinema</i> sp.
<i>Hoplolaimus</i> sp.	
<i>Meloidogyne</i> sp. (larvae)	(Doubtfully Identified)
<i>Paratylenchus</i> sp.	<i>Macrotrophurus</i> sp.
<i>Pratylenchus</i> sp.	<i>Pseudhalenchus</i> sp.
<i>Rotylenchulus</i> sp.	<i>Trophurus</i> sp.
<i>Rotylenchus</i> sp.	(Unknown Form)
	<i>Tylenchoidea</i>

Extract from Report of the Entomologist

A severe outbreak of the Gelatine Grub (*Niphadolepis alianta* Karsch, Cochliidiidae), a phylophagous, polyphagous pest, was reported from an estate at Cholo in April this year. A large area of the estate was severely damaged.

The last serious attack by this insect on tea occurred in 1938 on two estates at Cholo in May, but spread to a few other estates in the following years. The pest continued to be numerous on some estates at both Cholo and Mlanje until 1941 when it became scarce again.

A questionnaire was distributed in May, 1961, to all tea estates, and various estates at Cholo and Mlanje were visited. As a result it was discovered that four estates were infested at the time; two of them, one at Cholo and one at Mlanje, were seriously affected. These outbreaks were controlled, and by July the situation was normal on all estates.

From the evidence available the following conclusion have been drawn:

1. The Gelatine Grub is not likely to become a major, widespread pest, but, although serious outbreaks are rare, severe or even devastating attacks are possible locally, and it is most important for estate managers to be aware of this possibility.
2. In the past, attacks have been reported only when the infestation has been at, or near, its peak. It is then too late to do more than prevent the spread of the pest to other areas on the estate, or to other estates.
3. Large numbers of the Gelatine Grub may occur from early February until May or June. The most likely period for peak numbers is in April or May but several major factors are chiefly responsible for the increase and the build-up will depend to some extent on unknown limiting factors in any particular area.
4. A careful watch for any increase in larval numbers is necessary from November onwards, therefore, especially for the next few years. Immediate chemical control measures should be taken if ten or more grubs are discovered in an examination of a sample of twenty bushes. Hand-picking and killing by dropping the larvae and pupae in oil or paraffin is beneficial when numbers are below this level. Dusting of the ground around the trunk, and the trunk of the bush itself, with 5 per cent. dieldrin or D.D.T. dust also helps to keep an infestation within bounds. All prunings should be burnt or buried around infested bushes and as little refuse as possible left at the base of such bushes.
5. There is some evidence to show (a) that the grub commences its attack on the older leaves of the tea plant and gradually proceeds to the newer flush; (b) that poor stands of tea are more prone to attack.

6. In the case of a heavy infestation, a fair control has been achieved by spraying 50 per cent. D.D.T. wettable powder at a rate of one pound in 40 gallons of water spraying the foliage to run-off and not neglecting to spray the undersides of the leaves. Control by means of D.D.T. is only really effective when applied properly, however, and a complete control in an area is rarely to be found due largely to poor spray coverage. Slight taint was reported in one instance of D.D.T. spraying but normally no taint occurs.

7. Excellent control with a very rapid kill was found after spraying with Sevin 50 per cent. wettable powder at one pound in 50 gallons of water on areas on two estates where 100 or more grubs occurred per bush. Sevin is recommended as a control in the case of any serious outbreak. No taint or phytotoxic symptoms occurred using this insecticide. The 85 per cent. sprayable formulation is recommended in preference to the 50 per cent. although it has not been used against the Gelatine Grub in the field.

8. Control of severe infestations over several acres by means of insecticides is difficult using any conventional sprayer due to the present lay-out and spacing of tea especially on older estates as the bushes are well grown and the branches intertwined and the spacing often closer than on more modern estates. The habit of the tea bush and the method of pruning also makes it difficult to obtain a good cover spray.

9. The use of a fogging-machine (using Lindane) enabled many more bushes to be treated in a much shorter time than the use of pneumatic knapsack sprayers, but even under ideal climatic conditions individual bush cover is not as good as with a spraying machine, and the general cover is poor resulting in a 50 per cent. or more survival.

10. Tea in Nyasaland has been, and still is, remarkably free from serious pests, and regular or precautionary spraying is not advised. Spraying needs to be carried out only if the Gelatine Grub is numerous enough to justify it. Any regular spraying schedule would be likely to lead to outbreaks of pests that are at present of little consequence (e.g. red-spider) and insecticides are to be avoided except when absolutely necessary.

ALTERNATE HOSTS

Recorded hosts are rose-bushes, tung, *Glyricidia*, castor, apples, plums, custard-apple (*Annona* sp.), *Ficus* sp. (wild), *Hibiscus* spp. (wild and cultivated), *Pterocarpus* sp., coffee and blue-gum. No large numbers have ever been recorded on these hosts with the exception of coffee and blue-gum on rare occasions. There are other unrecorded hosts almost certainly.

PARASITES AND PREDATORS

Macrorhaphis acuta Dall. was discovered in some numbers on the two severely infested estates and in other areas. This Pentatomid bug feeds on the larvae of *N. alianta* but is not known to exercise any great degree of control.

A parasite, *Platyplectrus* sp., was also bred this season from larvae of the Gelatine Grub.

OTHER PESTS OF TEA

No other pest was recorded or reported as serious this season. Occasional specimens of *Parasa vivida* Walk., the Nettle Grub, also a Cochlidiid, were found, but damage was negligible. Minor *Helopeltis* damage was seen on one estate at Cholo.

Extract from Report of the Plant Pathologist

A few plants on Chombe Tea Estate, Nkata Bay, were killed by *Helicobasidium* sp.

Experimental work on *Armillaria* control is given in the Senior Agricultural Chemist's report.

Gnarled stem canker of young tea plants in nurseries due to attack by the bug *Helopeltis* sp. was not uncommon during the year, a year when rainfall was nearer normal after two dry years.

Abstract of Third Annual Report (1960 '61) on Research into the Biochemistry of Tea Fermentation

by

D. S. Bendall and R. P. F. Gregory

Department of Biochemistry, University of Cambridge

One of the main methods of studying the problems of fermentation in Nyasaland tea has been to compare the polyphenol oxidase activities and total polyphenol contents of green shoots from individual bushes, with the colour of the liquor obtained from the fermented leaf. The results have shown that there is a continual variation amongst the bushes, so that no sharp distinction exists between a class of good fermenters and a class of poor fermenters; most bushes are in fact of medium quality. The one exception is a small proportion of bushes (estimated by the Plant Breeder to be about 5 per cent. of the total) which ferment extremely slowly, showing scarcely any sign of fermentation in 24 hours. The indications are that a deficiency of polyphenol oxidase causes this condition, but further analyses on similar bushes are needed to confirm the conclusion.

At least three kinds of poor fermentation can be described:

1. A low rate of fermentation due to a low polyphenol oxidase activity. This does not appear to be deleterious as far as liquor colour is concerned provided fermentation is continued long enough.

2. A weak liquor due to a low total polyphenol content; undoubtedly a serious cause of trouble.

3. A dull liquor, associated usually with a relatively low proportion of theaflavins in the liquor, though there are signs that variations in the colour of the thearubigins may also be important.

In actual bushes combinations of the above types of poor fermentation may occur. In the factory the situation is more complicated because fermentation is carried out on a very mixed sample of leaf and the initiation of fermentation in different pieces of leaf takes place over quite a long period of time.

The comparisons made last year between leaf samples from Nyasaland and Ceylon have been extended by similar measurements on samples from selected bushes at Tocklai. Although the best Tocklai sample gave a strong bright liquor, and was rich in both polyphenols and oxidase, these characteristics were not outside the range observed with Nyasaland bushes, except that the liquor was slightly stronger than has yet been found in Nyasaland. On the whole these results confirm the opinion that high quality bushes are to be found in Nyasaland.

Some of the factors which may affect the course of fermentation have been studied, bearing in mind the possibility of improving the colour of the liquor. Further investigations on the influence of acetic acid on fermentation, particularly in factory trials by the Plant Breeder, have given disappointing results, as no consistent improvement has been reported by the tasters. In the study of other possibly important

factors the sand-grinding method of fermentation has been used, where necessary adding small volumes of the appropriate reagent during grinding. A striking effect was obtained in this way with relatively large amounts of vitamin C (sodium ascorbate) which, in addition to delaying the onset of visible fermentation inhibited almost completely the formation of theaflavins during the subsequent fermentation. A very dull liquor was thus produced. The investigation of the mechanism of this effect should help us to understand the processes of theaflavin and thearubigin formation during fermentation. We have concluded, however, that the smaller amounts of vitamin C normally occurring in the leaf have little influence on fermentation.

Of more immediate importance was the finding that small amounts of water added to unwithered leaf at the beginning of fermentation had a slightly beneficial effect on the proportion of theaflavins formed. This observation agrees with a previous one that withering lowered the percentage of theaflavins, and throws some light on the results of different methods of manufacture.

A further effect which may prove to be of practical significance was found with hydrogen peroxide. Tea leaves are known to contain peroxidase in addition to polyphenol oxidase. Peroxidase is also an oxidizing enzyme, but whereas polyphenol oxidase catalyses the oxidation of polyphenols by oxygen, peroxidase uses hydrogen peroxide as the oxidizing agent instead of oxygen. In a particular sample of tea leaf peroxidase was found to be at least ten times more active than polyphenol oxidase, and there is evidence that this difference may be general. As a consequence sand-ground leaf can be completely fermented in about 10 minutes by slowly adding hydrogen peroxide. Any deficiency of polyphenol oxidase might thus be overcome using hydrogen peroxide, but various questions arise, such as whether aroma can be fully developed, before its practical value can be assessed.

The influence of temperature on fermentation has been investigated. At a lower temperature the rate of fermentation is decreased, but there is evidence that at the same time a higher proportion of theaflavins is produced. A low temperature of fermentation should therefore improve quality, but there is some inconsistency in the results and this interpretation should be regarded as tentative.

The well known influence of the standard of plucking on quality has led us to measure the fermentability, polyphenol oxidase activity and total polyphenol content of different parts of the shoot. The highest oxidase activities were found in the young stem, that is between the tip (with the bud removed) and a point half way between the second and third leaves. The bud also contained a high enzyme activity, but it was appreciably lower in the first leaf and declined steadily as the leaf became older. The bud and first leaf were rich in polyphenols, the concentrations declining again as the leaves aged. The stem had a low polyphenol content. As would be expected from these results, fermentation was rapid in the young stem but a weak liquor was produced. The bud, and first and second leaves gave strong liquors and the older leaves weaker liquors. Relatively bright liquors were given by the bud, first, second and third leaves, but the proportion of theaflavins in the liquor declined rather sharply in the fourth and older leaves. The liquors given by the stem had a high proportion of theaflavins with very short periods of fermentation but with normal fermentation times the percentage was comparatively low. These results provide a scientific basis for what has long been recognized in practice, namely, that two and a bud is the best standard of plucking. When further elaborated they will help us to understand the role of the polyphenols in fermentation.

Work on the purification and properties of polyphenol oxidase from tea leaves is progressing. The best preparation has been purified from the shoots by about 3,000 times with a 30 per cent. yield. Even so the enzyme has not yet been obtained in a pure state. Five fractions of enzyme with differing properties have been obtained.

Efforts at further purification are continuing, in order to establish whether this means there are five different enzymes involved. It is considered likely that in fact only one or two enzymes are present.

Little work has yet been done on the properties of the polyphenol oxidase, but the enzyme has been found to occur in fermenting leaf in a relatively inactive state. When freshly-ground leaf is shaken with a large volume of water the activity of the enzyme is increased about five times. If the enzyme could be made to exert its full activity a rapid fermentation would be obtained with leaf relatively poor in polyphenol oxidase. The cause of this phenomenon is being investigated.

We have been collaborating with the Plant Breeder in evolving methods suitable for fermentation testing in selection and breeding, and more recently methods for the estimation of polyphenol oxidase and total polyphenols. The earlier finding that chlorophyll is not destroyed during fermentation, plus the Plant Breeder's observations on teas made from normal and albino flushes, have strongly suggested that the concentration of chlorophyll is very important in determining the colour of fermenting leaf and of the infused leaf from the made tea. A bright copper colour during fermentation does not seem to indicate that the liquor will be necessarily bright. The albino tea gave a dull liquor associated with a very bright infusion, and one would expect conversely to find teas with bright liquors associated with dull infusions. A high concentration of chlorophyll is likely to impart a dull colour to the fermenting leaf and to the infusion.

A direct comparison of the liquor colours produced as a result of fermentation in chloroform or by sand-grinding has shown that fermentation proceeds relatively slowly in chloroform. The chloroform test as ordinarily performed assesses only the rate of fermentation, which is determined mainly by the polyphenol oxidase activity. Other fermentation tests measure mainly the final strength of the liquor when fermentation is complete; here total polyphenol content is the most important factor. These differences do much to explain the disagreement which is sometimes observed between the chloroform test and other tests such as mincing, sand-grinding, or miniature manufacture. They by no means invalidate the chloroform test as a preliminary selection technique, but they do demonstrate the need to supplement the simple test by other methods of assessment. Indeed, modification of the chloroform test so that the leaves are observed after a number of hours as well as at 90 minutes might well supply the required information.

The final observations to which we wish to refer in this report concern measurements on colour formation during normal factory manufacture. Samples were taken from the fermenting trays immediately after roll-breaking and at intervals thereafter, and immediately fired. Measurements on the colour of the liquors showed that optimum brightness, as measured by the proportion of theaflavin colour, occurred at an early stage in fermentation (at about $1\frac{1}{2}$ hours). On the other hand these teas tasted rather raw and the optimum fermentation time taking all liquor characteristics into account was appreciably later. Direct colour measurements on the liquor do not therefore find ready application to the control of factory fermentation.

We are continuing to study the chemical mechanism of fermentation as a fundamental understanding of the process gives us the best hope of being able to improve on the present standards. These studies involve a knowledge of the behaviour of both the enzyme and the polyphenols in fermentation. We have already found for example that normal colour formation takes place in a reconstituted system consisting of a crude preparation of polyphenols and partially purified oxidase. As a development of this we hope soon to have the enzyme, and each of the individual polyphenols, in a fully purified state. Fermentation may then be studied in a system in which all the variables can be controlled. Comparison of such experiments with the behaviour of the whole leaf should give rapid advances in our knowledge.

Work is also planned to elucidate further the differences between good and poor fermenters, in particular the relative concentrations of the different polyphenols in different bushes. We also hope to make general comparisons between Nyasaland teas and those from Assam and perhaps other countries by measurements on the colour of the liquors from the made teas.

SUMMARY

1. Three types of poor fermentation can be described: a low rate of fermentation due to a low polyphenol oxidase activity, a weak liquor due to a low total polyphenol content, and a dull liquor associated with a low proportion of theaflavins and possibly other factors.

2. Comparisons of green leaf samples from Tocklai and Nyasaland have confirmed that high quality bushes occur in Nyasaland.

3. The influence of various factors on colour formation during fermentation have been studied. A high water content of the fermenting leaf improved the percentage of theaflavins in the liquor. A similar effect was sometimes, but not always, obtained by lowering the temperature of fermentation.

4. Complete fermentation occurred in 10 minutes on addition of hydrogen peroxide to macerated leaf.

5. Studies on the fermentability, polyphenol oxidase activity and total polyphenol content of various parts of the shoot have emphasized that two and a bud is the best standard of plucking.

6. The significance of the chloroform test has been clarified.

7. A 3,000-fold purification of polyphenol oxidase from tea leaves has been achieved, and work is continuing with the immediate aim of establishing whether more than one polyphenol oxidase is present.

8. It is hoped soon to study the mechanism of fermentation in a fully purified system. Work is also continuing on the differences between good and poor fermenters, and on possible practical applications.

METEOROLOGICAL STATEMENT, MIMOSA, MLANJE DISTRICT, 1960/61 SEASON

Mimosa Station Latitude 16° 05 S., Longitude 35° 36'E., Elevation 2,110'.

Month	Rain ins.	10 year mean ins.	Max. °F.	6 year mean °F.	Min. °F.	6 year mean °F.	Thermograph mean daily °F.		Mean daily dev. point °F.		Daily sun hours		Wind m.p.h.		Penman Est. Ev. ins.		Pan evaporation ins.	
							1 actual	9	1 actual	9	1 actual	9	1 actual	6	1 actual	6	1 actual	6
1960 July	3.31	1.31	75.3	74.3	52.2	52.2	30.7	62.2	55	33	3.5	5.3	93.3	47.74	3.52	3.3	3.52	3.80
August ..	0.06	1.54	84	77.0	53.0	53.0	63.1	63.0	3	25	9.0	7.1	82.33	33.3	1.65	3.3	1.65	1.52
September	3.89	1.41	83.4	84.0	57.5	58.8	63.8	63.4	37	33	7.8	7.8	79.22	73.27	2.3	3.3	2.3	3.13
October	0.23	1.00	89.1	89.2	61.9	62.3	70.0	70.3	30	38	8.7	8.7	36.91	77.45	2.44	3.3	2.44	8.15
November	2.54	7.65	90.2	89.0	64.0	65.3	73.0	73.0	42	43	7.8	7.8	82.33	73.45	7.63	3.3	7.63	5.11
December	7.61	10.54	87.1	85.2	60.9	62.1	72.7	74.0	33	37	4.1	4.1	26	33.45	3.73	3.3	3.73	3.78
1961 January	11.42	11.62	85.3	83.7	63.8	64.3	73.1	73.5	32	37	3.7	3.7	33.33	33.45	3.73	3.3	3.73	5.92
February	12.25	12.11	84.1	82.7	65.0	65.3	72.3	73.6	33	39	3.7	3.7	11.33	33.45	3.73	3.3	3.73	4.70
March ..	15.22	12.06	84.0	84.8	67.2	67.2	73.3	72.1	39	47	4.0	4.0	11.33	33.45	3.73	3.3	3.73	4.98
April	3.07	5.86	83.0	81.6	64.9	65.3	72.1	70.6	33	33	4.0	4.0	33.33	33.45	3.73	3.3	3.73	4.67
May ..	1.67	2.64	81.6	80.0	57.7	57.3	63.1	63.3	42	39	3.4	3.4	36.33	33.45	3.43	3.3	3.43	4.51
1961 June	0.85	2.00	77.5	73.9	53.8	53.1	63.0	62.3	35	33	3.7	3.7	33.33	33.45	3.43	3.3	3.43	3.36
TOTAL	63.60	69.74	—	—	—	—	—	—	—	—	—	—	—	—	64.42	64.51	59.1	64.63

TUNG

1. Production of Improved Planting Material

1. SELECTED SEEDLINGS

High yielding seedlings, recorded over a period of years on local estates, were propagated vegetatively at Bvumbwe by budding in 1947 and planted in a series of four clonal trials.

The layout of each trial was a randomized block and there were nine, eleven, eight and four varieties respectively in the four trials.

The trees have been cropped for twelve years but no records were taken until the third crop was harvested. Table I shows the clones which have consistently given the highest yields over the first ten years.

TABLE I
High-Yielding Clones from Trials Planted in 1947
(Yield in lb. air dry seed per acre)

Clone				Mean yield per year				Mean, 10 years		Type
				1952 6 years old	1953-56 7-10 years old	1957-60 11-14 years old	1961 15 years	per tree	per acre	
E565	..	..	..	426	1,029	2,174	2,206	26.1	1,459	Vig. B
G69	..	..	..	381	988	2,209	2,251	26.0	1,457	A to Vig. B
G96	..	..	..	622	1,152	1,915	2,005	25.4	1,424	A.
G87	..	..	..	342	1,044	2,173	1,954	24.6	1,378	Vig. B
G88	..	..	..	370	1,014	2,037	2,089	24.6	1,378	A.
G112	..	..	..	571	1,121	1,884	1,809	24.1	1,349	Vig. B
G43	..	..	..	370	1,026	1,940	1,960	23.6	1,324	A.
G57	..	..	..	409	906	1,889	1,635	21.6	1,210	Vig. B
E623	..	..	..	218	769	1,569	2,173	21.1	1,182	A.
M13	..	..	..	666	810	1,786	1,529	21.4	1,198	A.
10	..	..	..	302	893	1,434	1,266	17.4	974	Vig. B

In the table they are compared with two widely-planted clones, M13 and 10, of the same age and in the same field. There is evidently better planting material available in this new collection of clones.

2. LEGITIMATE SEEDLING FAMILIES

Observation plots have been planted at Bvumbwe of clonal material taken from the fifteen high-yielding seedlings detailed in last year's report. The trees have established well and can be expected to give even higher yields than those shown in Table I.

2. Fertilizer Trials

The fertilizer trials at Bvumbwe and Mzuzu continue and will be reported in full next year.

3. Other Experiments with Tung

1. PASTURES UNDER TUNG

This experiment at Bvumbwe was reported fully last year. The pasture of *Paspalum notatum* has now induced a marked depressing effect upon the yield of the trees, even at the highest rates of fertilizer (see table below).

TABLE II
Effect of Grassing-down a Tung Plantation
(Yield of air dry seed, lb. per acre)

Treatments	Rate of sulphate of ammonia per tree (lb.)				
	0	2	4	6	Mean
Clean cultivation	644	868	1,173	1,095	945
Paraguay <i>Paspalum</i>	308	344	409	633	424
Pensacola <i>Paspalum</i>	258	479	330	680	437
	403	564	637	803	—

Low. sig. diff. fertilizer means $p=0.05$, 229
0.01, 316
treatment means $p=0.05$, 279
0.01, 386

Coeff. of variation, 11.5 per cent.

The pasture is grazed by Dorper sheep. Because of the incidence of worm infestation the experiment has had to be divided into six paddocks for rotational grazing, each paddock being grazed one week in six. It has been possible to keep between 4 and 5 sheep to the acre on the pasture for only 153 days in the past year. For the remainder of the time there has been insufficient grazing and supplementary feeding has had to be introduced.

2. CLOSE SPACING OF TUNG

The experiment planted in December, 1957, was reported fully last year. Considerable interest has been shown in this trial and the figures for the current season's crop are now reported.

TABLE III
Close-Spacing Trial, 1961
(Mean yield, lb. air dry seed per acre)

	Spacing			Mean
	7'6"	10'	15'	
Pure-stand B-type ..	1,982	863	431	1,092
Interplanted with A-type ..	1,458	741	392	864
	1,720	802	412	

L.S.D., spacing $p=0.05$, 463
0.01, 673
Coeff. of variation 49.2%

Yields from trees at the closest spacing are comparable within four years of planting to those obtained from high yielding clones in Table I in their tenth year. The trees have now formed a closed canopy at a 7 ft. 6 in. spacing.

PUBLICATION

FOSTER, L. J. 1962. "Recent technical advances in the cultivation of the tung oil tree, *Alseodaphne montana*, in Nyasaland." *Tropical Agriculture*, in print for Vol. 39, 3, July, 1962.

The results of investigations for the ten years 1950-1960 are reviewed.

Extract from Report of the Senior Agricultural Chemist

TUNG OIL

STATUTORY ANALYSIS OF EXPORTED OIL

The continued improvement in prices has maintained interest in the oil, and factories have received supplies of nuts from several smaller estates, which had previously ceased collection. The total production from the 1960 crop (i.e. expressed in the latter half of 1960) was 1 093 tons, the distribution of exports being shown below. These are in order of quantity and it is interesting to note that the various parts of Africa take first place. Japan also still continues to be a major consumer.

	Africa	U.K.	Japan	Europe (not U.K.)	U.S.A.	Australia
Tons	404½	270	205	112½	100	1
of whole	37	25	19	10	9	—

These figures include 14½ tons of oil from *Alseodaphne fordii*, which was exported to Norway.

Of these amounts, the two Southern Province factories produced 435 and 433 tons, while that in the Northern Province expressed 225 tons of oil.

The value of this statutory control was not only seen from the maintenance of exports at a time of low prices, but it has an effect on the growers to maintain the quality of the seed sent to the factories. Thus, over the years, the importance of early and dry harvesting and good storage in dry conditions has been realized. Consequently, this season over 90 per cent. of the oil produced had a free fatty acid content of less than 1.5 per cent., well within the B.S.S. maximum of 2.5 per cent. This consistency of quality is shown by the following figures:

% Free Fatty acids	<0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5
No. of Consignments	13	57	11	6	2
Tons	163	690	142	76	22
% of whole	15	63	13	7	2

COMPOSITION OF TUNG OIL

The better acidity control—referred to in the preceding paragraph—has been reflected in more steady figures for the gelation tests. Oil from the two Southern Province factories has shown a least test figure of 21-25 minutes in the B.S.S. Test, and 13-14 minutes in the Worstall Test. The Northern Province factory's oil was in the range of 26-27, and 15-16 minutes respectively. The importance of acidity control in this connection is seen from the fact that an increase in acidity of 1 per cent. in any particular *montana* oil, will lengthen the gelation time by about 2½ minutes, although of course the effect of minor compositional variation between oils of different clones must also be taken into account. As the period of this report overlaps the commencement of expelling of the 1961 crop, it may be commented that the longer and heavier rains in the Northern Province have led to harvesting problems—but by control of the seed at the factory, it has been possible to produce oil, largely within the B.S.S. limits of acidity, although a minor quantity of oil of 3 per cent. acidity occurred.

Following the decision of the British Standards Institution not to introduce a modified Worstall Test for their specification, they have been advised that the maximum figure allowed for the gelation time of *montana* tung oil, under the current method of determination, should be increased from 26 to 28 minutes.

TUNG OIL UTILIZATION

The investigations being made by Dr. Chatfield have continued, and at his suggestion, these have been at a less intensive rate, following the conclusions of his initial survey. Tung oil has been shown to improve "scrub-resistance" of existing emulsion paints, and the low acidity of Nyasaland oil as described above, would make the oil of particular value in the production of insulating varnishes.

COFFEE

1. Cultivation and Manurial Trials

1. SHADE/MULCH/MANURIAL EXPERIMENT

The experiment at Bvumbwe, described in detail in last year's report, continues. The coffee had been converted to the second cycle and a very small crop, which showed no significant difference between treatments, was developed. The three suckers, arising during conversion, grew to a height exceeding six feet (183 cm.) and developed primary bearing shoots. The strongest and healthiest suckers were produced in the unshaded, mulched plots (see Table I). Under the dense *Albizzia* shade, suckers were so weak and etiolated that they had to be supported; internodes were long and a poor primary branch system exists. During the year seven deaths resulted from attacks of *Fusarium* dieback disease, *F. stilboides*; all were in shaded plots, six under *Albizzia*. The *Albizzia* trees have now been thinned to a 36 foot square, instead of a quincunx planting.

TABLE I
Development of Suckers in Shade/Mulch Experiment

Treatment	Bvumbwe			Gala
	Mean Sucker Height (cm)	Mean Sucker Girth (cm)	Trunk Girth (cm)	Mean Sucker Height (cm)
M. No shade, mulched with napier	214.1	9.7	31.6	94.5
(l) <i>Grevillea</i> shade, mulched with napier	195.2	8.3	25.2	44.2
SM. <i>Albizzia</i> shade, mulched with napier	189.9	7.8	25.4	64.5
S. <i>Albizzia</i> shade, mulched with tang hulls	177.5	7.2	23.6	63.0
L.S.D. $p=0.05$	23.6	1.1	1.5	—
$p=0.01$	32.0	1.5	2.3	—
Coeff. of variation	5.9%	6.7%	6.0%	—

Suckers measured 19 months after cutting back.

Similar results were obtained at Gala, where a few plots of the original shade mulch experiment remain. The *Grevillea* plots were not mulched at first and the effect is clearly marked.

There was no significant effect due to fertilizers.

Conversion to the second cycle. It was reported last year that sucker production was more satisfactory where one bearing stem had been removed than where both stems were allowed to bear a further crop. But, as Table I shows, the growth rate of suckers was very rapid and they will probably be unable to bear more than two or three crops before the trees have to be converted again. Several other methods of converting were tried with the object of reducing the rapid sucker growth (see Table II). If the time of pruning the head was delayed until December, there was no difference from pruning immediately after the harvest. If both heads were cut to the lowest primaries or to six inches from the ground, sucker growth was just as rapid; there was the added disadvantage of losing the whole crop for one year. There seems to be no better method of converting than to remove one bearing head in the year when suckers are required. A high growth rate is inevitable in the climatic conditions of Nyasaland. The management of trees in the second cycle is now being studied.

TABLE II
Conversion of Coffee to the Second Cycle

<i>Treatment</i>					<i>Mean Height of Suckers (cm), June, 1961</i>
Prune one stem, September, 1960, to the lowest primary	..	..	..	..	78.0
As above, in December, when rain commenced	..	..	..	..	77.8
Prune both stems, September, 1960, to lowest primaries	..	..	..	..	71.6
Prune both stems, September, 1960, to 16 in. from the ground	..	..	..	..	78.7
Low. sig. diff. $p=0.05$	..	..	..	..	15.7
Coeff. of variation	..	..	..	..	18.2%

2. OTHER INVESTIGATIONS IN SHADE, MULCH AND FERTILIZERS

The *Albizzia* shade in the variety trial has now formed a complete canopy which tends to produce a depressing effect upon the crop. This may be welcomed as a method of controlling overbearing, but cannot be recommended because of the difficulty in obtaining suckers when grown on a multiple stem system and because of the etiolated growth.

TABLE III
Effect of Albizzia Shade—Bvumbwe
(Yield, clean coffee per acre)

				<i>Mulching Material</i>	
				<i>Napier</i>	<i>Sawdust</i>
<i>Albizzia</i> shade	..	..	..	1,132	701
No shade	..	..	..	1,408	1,101

Coffee growing under tung at Bvumbwe is markedly etiolated and many of the trees, which are not yet in bearing, are already six feet high, about eighteen inches to two feet higher than those of the same age in the open. Those pruned on the single stem system are forming a branch framework satisfactorily and it appears that, if coffee is to be grown under tung, the single stem system must be employed. It has already been noted that the incidence of *Fusarium* was greatest under shade. This was because weak suckers are highly susceptible. No suckers are produced when coffee is grown on the single stem system.

The effect of shade trees, over the past few years, upon the moisture available to coffee is discussed in the Soil Physicist's report.

The damage to young trees by a high rate of nitrogenous fertilizer, reported last year, was investigated further at Bvumbwe.

Layout: 4 × 4 Latin square, plots of eight trees each.

Treatments:

- Main plots.—Fertilizer ..
1. Sulphate of ammonia.
 2. Calcium ammonium nitrate (C.A.N.)
 3. Urea.
 4. Farmyard manure.
- Sub-plots.—Rate ..
- (a) High level, 1 and 2 at 8 oz. per tree, 3 at 4 oz. and 4 at 100 lb.
 - (b) Low level, 1 and 2 at 4 oz. per tree, 3 at 2 oz. and 4 at 50 lb.

- Application (i) Wide band well mixed with soil.
 (ii) Narrow band not mixed with soil.
 (iii) Near stem of tree.
 (iv) Near stem of tree and on leaves.

Results: The fertilizers were applied one month after planting; the trees were scored. In the first month after the application of fertilizers, sulphate of ammonia and calcium ammonium nitrate, when placed near the trees, induced a marginal chlorosis and sometimes defoliation. In severe cases there was collar rot, and death occurred. When applied on the foliage, the trees defoliated. Dung, when placed near the tree, induced a few cases of collar rot. Within six months from planting, more damage was done by urea at the high rate than by other fertilizers.

The experiment has indicated that least damage occurs when the fertilizer is applied in a broad band around the tree not less than six inches from the stem, but keeping within the spread of the branches. In the first year it is dangerous to apply more than two ounces of C.A.N. or sulphate of ammonia per tree per application; there is no reason why two applications should not be made during the rains.

In a dung mulch observation at Katobo, altitude 3,640 feet, in the Misuku Hills of Northern Province, mulch of *Hyphantornis* was essential and dung, when applied as a top dressing of one *disie* per tree, was beneficial only on mulched coffee.

TABLE IV
 Dung Mulch Observation—Katobo
 (*Cican coffee, lb. per acre**)

	1960	1961
No dung, no mulch ..	7.8	20.4
Dung, no mulch ..	3.6	63.9
No dung, mulch ..	333.0	789.3
Dung and mulch ..	443.7	1,633.0

* Estimated from cherry weight assuming a cherry/coffee ratio of 6 : 1.

If coffee suffers a severe moisture stress, it is evidently unable to take advantage of the extra nutrients provided by the dung. The dung is valuable as a source of nutrients and not for the mechanical effect it has, when applied as a top dressing, on moisture retention.

At Mzuzu (Choma) the $4 \times 2 \times 2$ N.P.K. manurial factorial experiment established last year has been changed to a N.P. and pruning trial. The growth rate of coffee in Nyasaland is abnormally high, particularly in the hot period preceding the rains, and it is becoming necessary to modify the system of multiple-stem pruning normally recommended. This experiment will be reported in detail when the first crop is harvested.

A similar experiment was planted at Nchenachena, using a 4×3 design with four replicates. Establishment was excellent and deaths amounted to less than one per cent. It soon became obvious that exposure was an important factor and additional protection in the form of bananas was planted around the experimental area. Plants in the variety plots, which filled the margins to the experiment, were protected with grass shelters. These were greener and healthier than those in the main experiment which were less sheltered.

Other fertilizer experiments at Katobo failed to show any significant response because of the high coefficient of variation, due to the effects of exposure in past years.

3. WATER REQUIREMENTS OF COFFEE

In previous trials the coffee was not irrigated. Now it has been shown that coffee can be grown successfully without irrigation its effect is being assessed when introduced as a supplemental treatment.

In order to estimate the depth of soil through which the roots of a coffee plant are able to obtain water, the root system of an eight-year-old tree of N. 39 was washed out at Bvumbwe. There was a good system of roots to a depth of eight feet and some roots reached a depth of nine feet. There was no impeding layer. A tree in the same field was washed out two years previously; the root system had then penetrated to a depth of six feet, with a few roots at seven feet. Some roots had been delayed by a layer six inches thick of open quartz at a depth of 5 ft. 6 in. where there was a sudden drop in moisture content. This quartz layer occurs throughout the field, usually at a depth of five feet, but may be found as deep as ten feet. Both of the trees examined had a particularly dense root system in the region of the mulch which was situated between the rows. It can be assumed that, for the estimation of soil moisture requirements, roots of developing coffee trees penetrate in an unimpeded soil of the type described for Bvumbwe at a rate of one foot per annum.

At Cingaluwe, adjacent to Bvumbwe, an eight-year-old tree was also excavated. The root system was very shallow and was contained mostly in the upper two feet. Some very fine hair-like roots penetrated to a depth of four feet. The soil became mottled at about four feet with nodules of soft laterite, evidently as a result of leaching. This presented an impeding layer to the root system. The trees were healthy, but were prevented from bearing heavy crops by a rather dense shade of indigenous trees, mostly *Brachystegia*, the roots of which were able to penetrate to a depth of ten feet.

TABLE V
Acidity of Two Coffee Soils

Depth (in.)	Bvumbwe		Cingaluwe
	Area 1	Area 2	
0-6	5.7	5.7	6.2
6-18	5.4	5.3	6.4
18-30	5.3	5.3	5.8
30-42	5.1	5.2	5.6
42-54	5.1	5.1	5.6
54-66	5.1	5.1	5.5
66-78	5.0	5.0	5.6
78-90	5.4	5.0	5.6
90-102	5.2	5.1	5.6
102-114	5.2	—	5.6
114-126	5.1	—	5.6

The table shows that the soil was more acid throughout its depth at Bvumbwe than at Cingaluwe. The physical structure of the soil and not its acidity appears to be a limiting factor to the development of a coffee root system.

The irrigation experiment at Bvumbwe, described in detail in last year's report, continues. Readings from gypsum soil moisture blocks were taken twice weekly and periodic gravimetric soil samples were taken to determine the amount of moisture

available and the amount of irrigation required. Detailed results are given in the Soil Physicist's report. Two irrigations were necessary this season at the normal flowering time, in October and November, 1960, to maintain soil moisture at three quarters field capacity to a depth of eight feet. The coffee has been converted to the second cycle and, as the new shoots which had arisen after conversion had been unable to develop many flowers, practically no crop was borne. Soil moisture was adequate at the time when the crop would normally be maturing and no irrigation was then necessary. Irrigation advanced the time of flowering and the commencement of leaf growth but no difference in the length of the shoots or their girth or of the main trunk could be attributed to irrigation treatments.

It is possible that the trees would benefit from a higher rate of irrigation and the investigations have been extended to include observation plots in which the trees are irrigated according to water balance sheets using data from a standard evaporation pan. The trees are watered when the pan indicates a deficit of 2, 4 or 6 inches using a water rate factor of 1. From June to October, 1961, it has been necessary to water eight times on the 2 inches level, four times on the 4 inches level and 3 times on the 6 inches level.

Studies have continued on the effect of shade trees on the soil moisture available in the rooting-range of coffee, viz eight feet.

TABLE VI
Effect of Shade Trees on Soil Moisture, 1961

	Inches water available to a depth of eight feet		
	March	August	October
No shade, napier mulch	14.32	10.91	9.87
<i>Grevillea</i> shade, napier mulch	14.27	11.11	7.19
<i>Albizia</i> shade, napier mulch	14.11	10.02	7.61
<i>Albizia</i> shade, tung hull mulch	14.22	12.45	8.21

Albizia at first withdraws moisture at a higher rate than *Grevillea*; after August the position is reversed probably because *Grevillea* comes into leaf sooner than *Albizia*. When the coffee is mulched with tung hulls, instead of napier, a much higher quantity of moisture is retained in the topsoil.

2. Variety Trials

1. COLLECTION OF KENYA AND TANGANYIKA SELECTIONS

Location: Bvumbwe.

Object: To compare 27 seed selections from Lyamungu (Tanganyika) and Ruiru (Kenya) with a local selection from the Southern Province of Nyasaland.

Layout: Randomized block with eight replicates. Three plants per plot.

Varieties: From Tanganyika: H. 66, H. 133, I. 60, KP. 128, KP. 163, KP. 228, KP. 423, L. 1, N. 5, N. 39, N. 81, N. 197. From Kenya: Ke. 20, K. S.A. (Kapretwa series A), K. 7, Kent's Hybrid, SL. 6, SL. 14, SL. 28, SL. 34, Blue Mountain, Mocha, Geisha, Dalle Mixed, Maragogipe, Dilla and Alge.

Results: The yields for the first cycle, in which three crops were harvested, are shown in the table below.

TABLE VII
Coffee Variety Trial, Bvumbwe, 1959-61

(Yield clean coffee, lb. per acre corrected for vacancies and supplies)

Variety	1959	1960	1961	Mean for First Cycle
SL.28	1,924	1,711	861	1,495
KP.162	1,456	1,426	1,462	1,448
N.39	1,332	1,018	1,677	1,342
K.S.A.	1,235	989	1,536	1,253
SL.14	1,545	1,276	927	1,249
KP.128	1,388	914	1,382	1,228
SL.34	1,581	1,519	557	1,219
H.133	1,219	993	1,445	1,219
KP.423	1,436	1,269	809	1,170
Kent's	1,061	1,329	1,040	1,143
H.66	1,263	969	1,182	1,138
N.197	1,325	1,104	941	1,127
I.60	1,263	941	1,129	1,111
KP.228	1,053	949	1,261	1,088
N.81	1,425	800	1,027	1,084
Blue Mountain	1,202	1,135	863	1,067
SL.6	906	989	1,274	1,056
Ke.20	941	922	1,295	1,053
N.5	972	845	1,231	1,016
Dilla and Alghe	955	1,099	797	964
Geisha	1,147	1,048	501	899
K.7	985	1,126	549	887
Local	898	1,116	582	865
L.1	655	739	1,192	862
Dalle Mixed	360	853	1,264	826
Mocha	883	878	655	805
Maragopipe	827	889	625	780
Mean	1,168	1,068	1,039	1,089
L.S.D. $p=0.05$	220	395	Not Sig.	
$p=0.01$	380	517		
Coeff. of Variation	37.8%	37.7%	77%	

High winds in January, 1961, damaged many primary branches and the crop was patchy. The results show that the experiment produced about the same mean yield, around 1,089 lb. each year. There was some variation in the order in which the varieties were placed year by year. Some varieties are evidently not capable of producing a high yield each year, e.g. KP. 128, I. 60, H. 66, N. 81 which show a tendency to biennial bearing. *Dalle Mixed* takes some years to reach maturity. KP. 162 has been a consistently good yielder although, in the observation plots of Tanganyika selections, it was the lowest yielder.

It is generally conceded that in coffee variety trials the results of about six crops are required for a final assessment. At this stage the general trends can be noted and may be of use because varieties suitable for local conditions are urgently required. It seems quite safe to recommend the three Scott Laboratory *typica* selections SL. 28, SL.14 and SL.34. Of these SL.28 is highly susceptible to *Fusarium stilboides* and SL.14 and SL.34 show some resistance. They produce beans very acceptable to the trade. None are resistant to the Nyasaland race II of *Hemileia vastatrix*; the only high yielding variety resistant to *Hemileia* is KP.423 and this again was not outstanding in the observation plots. N.39 is a useful Tanganyika *Bourbon* strain which retains its foliage well and is a consistently high yielder everywhere. The *Local Bourbon* strain can evidently be bettered and it yields somewhere between *Blue Mountain* and *Mocha*

from which it has derived; There have been several vacancies of *Local* and *Mocha* in the trial and *Blue Mountain* has grown poorly elsewhere in the Shire Highlands. In another variety trial at Bvumbwe, not yet in bearing *Blue Mountain*, *Jamaica*, *Rume sudan* and *Mayagese Bourbon*, all from the Congo, suffered more from drought than a Kenya selection of *Blue Mountain*, SL.28 and *Kenya Selected Clone 33*, all from Kenya.

2. COLLECTION OF KENYA SELECTIONS

Location: Gala on the Limbe-Zomba road. This experiment, described in detail last year, continues to show the superiority of the three Kenya selections SL.14, SL.28 and SL.34. SL.28 developed more mbuni than last year and the trees were not as healthy at the end of the season as those of the other two varieties. Attacks of the leaf spotting disease *Cercospora* caused some defoliation which was worst in *Blue Mountain*.

TABLE VIII
Coffee Variety Trial, Gala, 1961
(Yield, clean coffee, lb. per acre)

Variety	Yield
SL.14	2,057
SL.28	1,417
SL.34	1,326
Brazil	1,243
Blue Mountain	626
Columnaris	346
Mean	1,169
Low. Sig. Diff. $p=0.05$	148
$p=0.01$	201
Coeff. of Variation	10.7%

3. VARIETIES AND PRUNING

Location: Bvumbwe.

Object: To compare the effect on five varieties of four different pruning treatments.

Layout: 5×5 Latin square.

Plot size 6×8=48 trees.

Sub-plots 3×4=12 trees.

Treatments: Plots. Varieties: 1. H.66

2. SL.14

3. SL.28

4. Kenya Selected, Clone 33

5. Kent's Hybrid.

Sub-plots—Pruning: All trees pruned on the multiple stem system.

(a) One stem in the first cycle. Crop after three years in the field. Prune to a three-foot head and allow secondaries up to three hand-breadths (10 in.) from the centre.

(b) Two stems in the first cycle. Crop at once. Prune as for (a).

(c) Two stems in the first cycle. Crop after three years. Prune as for (a).

(d) Two stems in the first cycle. Crop after three years. Prune to "break" and allow no secondaries.

The trees were planted in December, 1957. Variety 1, originally SL.6, failed to establish itself and was replaced by H.66 which is thus a year behind. Of the other varieties Kenya Selected proved to be a rapid grower and precocious bearer.

TABLE IX
Varieties and Pruning, Bvumbwe, 1961

(Yield, clean coffee, lb. per acre)

Pruning Treatment	Variety				Mean
	SL.14	SL.28	Kenya Selected	Kent's Hybrid	
(a) 1 Stem. Prune to 3 ft. head + Secondaries	1,317	984	1,125	1,025	1,113
(b) 2 Stems. Crop at once prune as for (a)	1,226	1,362	1,065	1,150	1,186
(c) 2 Stems. Prune as for (a)	1,495	1,275	1,262	1,257	1,322
(d) 2 Stems. Prune to "break" no secondaries	1,380	1,312	1,153	698	1,135
Mean	1,355	1,218	1,151	1,033	
Coeff. of variation	31%				

The high coefficient of variation is probably due to a combination of causes: attacks of *Colletotrichum* were serious in patches, and the trees were damaged, when young, by cutworms. There was no significant difference between any variety or pruning treatment. SL.14 and SL.28 are less precocious than *Kenya Selected* or *Kent's Hybrid* and produced no crop in pruning treatment (b) until the third year. The yields of trees which were allowed to crop in the second and third year were not markedly reduced, although defoliation was greater last year than in the other treatments. Trees with one bearing stem yielded slightly less than trees with two stems. It would be rash to conclude from this experiment that coffee can safely be allowed to crop as soon as it produces flowers. The disastrous results of allowing microplot trials in the Northern Province to crop early are mentioned in the next section.

4. VARIETY MICROPLOT TRIALS

These trials were fully reported last year. Further details will be available when the trees have come into bearing. Several plots have had to be abandoned during the year because they were unsuitable on account of drought, exposure or excessive temperature. In Northern Province plots were planted in the gardens of private growers who managed them as part of their own coffee. Although this arrangement saved the Department in cultivation expenses, it was unsatisfactory because district officers had little control over their management. The standard of mulching, weeding and pest control, particularly of stem-borer, has been at a lower level than on plots under the direct control of the Department and trees are dying in areas not necessarily unsuitable for coffee. The greatest difficulty has been to persuade growers to strip the first crop, when the trees are in their second year in the field; trees of varieties which have grown well and have borne a crop, died as the crop matured.

After allowing for the variable standards of management, it is possible to pick out the most promising areas on which it is worth concentrating. In Northern Province there are three areas, in the Katobo/Misuku area of the Misuku hills, on the eastern side of the Nyika north of Nchenachena to Livingstonia, and in the Nkata Bay Hills from Mzuzu to Upper Chikwina. The first two are the original coffee-growing areas. The third is being developed now; it is most promising because the growers have not inherited a tradition of bad management which results in biennial bearing and

short-lived trees. Under the guidance of officers of the Department trained in coffee growing, these new growers should adopt the methods, proved on experimental plots, to produce high yielding and long-lived trees. Areas on the western side of the Nyika are too dry.

In the Central Province the plots in the Dedza and Mwera Hill areas have had exceptionally good treatment, but the areas are too limited to justify their development. The plots in the Mwasamba Gochi area in the Kirk Range, on the boundary of Central and Southern Provinces, are promising and that area could probably be developed. The main coffee area in Southern Province is that part of the Shire Highlands around Bvumbwe, Cholo and Masambanjati. Some of the best coffee is produced here, mainly on estates, and the production is rapidly approaching the level of the Northern Province.

The *typica* selections from Kenya SL.28, SL.14 and SL.34 are generally promising varieties where they have been successfully established. The *Bourbon* selections from Tanganyika, N.197, N.81, N.5 and others, have established exceptionally well and have grown best on the sheltered sites; they have not been able to withstand exposure and have defoliated in the windy dry season after the rains. *Dalle Mixed* is a promising variety everywhere but, from experience at Bvumbwe, it produces a small bean of low quality. *Dalle Mixed* and SL.28 died after being allowed to crop prematurely in Northern Province; the crop was not a heavy one. *Rume Sudan* and *Blue Mountain* are not sufficiently drought resistant. S.288, resistant to the race of *Hemileia* occurring in Nyasaland, must be discarded for the same reason but K.7, another resistant variety, is more promising. The table below shows the first yields which have been recorded.

TABLE X
Coffee Microplot Trials, 1961
(Yield, clean coffee per acre)

Variety	Southern Province				Northern Province	
	Cholomwani	Konzalendo	Maonga	Kaombe	Tayali	Mwalalile
Brazil	756	450	746	870	134	—
Dalle Mixed ..	189	443	—	897	—	180*
H.66	792	209	—	891	—	—
Kent's	—	—	—	—	537	105
K.7	468	203	634	1,122	402	510
K.P.228	720	—	—	—	—	—
N.5	—	292	—	—	—	—
N.197	909	392	312	833	402	—
SL.14	711	338	891	—	—	—
SL.19	689	405	—	—	—	—
SL.28	797	337	913	854	—	—
SL.34	—	—	929	—	—	105*
Mean	670	341	738	912	369	225

L.S.D. $p=0.05$

165

191

Too many missing plots for analysis.

* Died after cropping

At Mwera Hill, Central Province, a plot of *Local* trees planted in 1952 has yielded the equivalent of 1,656 lb. clean coffee per acre. Younger trees have yielded 602 lb. per acre.

Some microplots have been planted to shade trees. In most instances the shade trees are not yet sufficiently grown to have any effect upon the coffee. At Gochi, Central Province, trees in the shaded plot were slightly less affected by extremes of temperature.

5. COFFEE LIQUORING TESTS

A report from Southern Rhodesia showed that the bulk of the coffee from Bvumbwe had been prepared carefully and the samples showed a noticeable improvement in the aromatic quality. The raw appearance was satisfactory and all samples produced a good roast, open and usually softish, with mainly white centre cuts.

Specially prepared samples of some of the most promising selections, *Brazil*, *Dalle Mixed*, N.197, SL 14 and SL 28 were sent to the Liquorer in Kenya. The raws were attractive but the liquors very thin. The thin liquor is attributed to the forcing conditions under which the crop is matured and it is therefore important to grow a variety which is least affected by local climatic conditions. It was considered that *Brazil*, SL 14 and SL 28 could produce coffee fully equal to the best Kenya coffee.

3. Age of Planting Material

1. The factorial experiment planted at Bvumbwe in December, 1958, described in last year's report, has not yet come into bearing. Growth measurements showed that the differences between the treatments had evened up a little. The 15-18-month-old plants were still superior to 12-month-old plants, but 12-month-old plants, whose roots had been planted with a ball of soil, were now as large as 15-18-month-old seedlings which had been planted with bare roots.

TABLE XI
Growth of Age of Planting Material after 30 months

Age when planted	Roots	Height (cm.)	Girth (cm.)
15-18 months	balled	173.4	15.4
12 months	balled	154.4	13.9
15-18 months	bare	152.3	13.2
12 months	bare	145.5	12.9
L.S.D. $p=0.05$		15.1	2.5
0.01		20.9	3.5
Coeff. of Variation		5.7%	8.7%

2. The above experiment was repeated at Bvumbwe two years later, in December, 1960, to observe the effect of another planting season and to include further additional treatments. Some planters were now claiming that six-month-old plants would be preferable if they are grown in polythene pots.

Full details of the experiment will be given in next year's report. The indications at the moment are that 18-month-old plants give a better stand than 12-month and 6-month-old plants.

4. Vegetative Propagation, Coffee

The work reported in 1958/59 was continued at Bvumbwe with the object of trying further rooting media and of perfecting the means of acclimatizing the plants when removed from the propagating frames.

Treatments

1. Leaf mould and coarse sand in the ratio 1 :1.
2. Coffee parchment hulls and sand in the ratio 1 :1.
3. Coffee hulls and vermiculite and coarse sand in the ratio 1 :1 :2.

All plants were treated with phymone (alphanaphthyl acetic acid), and single node cuttings were used.

TABLE XII
Rooting of Coffee Cuttings

<i>Rooting medium</i>	<i>Rooted</i>	<i>Not Rooted</i>	<i>Dead</i>
1. Leaf mould and sand	31	4	5
2. Coffee hulls, vermiculite and sand	27	2	11
3. Coffee hulls and sand	11	7	22

The cuttings were inserted late in September, and rooting took up to eight months compared with four months when taken in May. The quickest and best results were obtained from the leaf mould and sand mixture in which most cuttings had rooted by mid-December. Cuttings took longest to root in the coffee hulls, vermiculite and sand mixture; roots were finer and did not survive potting so well. The main precaution when potting the cuttings was to ensure that the soil was not rammed too hard. A potting mixture was made of two parts of the local sandy-clay loam and one part of the first rooting medium.

5. Cost of Coffee Production

The coffee unit attached to the mixed farm at Bvumbwe has run through a second year and will produce its first crop, a small one, next year. The cost for the current year is shown in the table below.

TABLE XIII
Cost of Maintaining a Small Coffee plantation, 1st July, 1960 to 30th June, 1961

				<i>Total Cost five acres</i>	<i>Per acre of coffee (÷ 5)</i>
3 acres of coffee in its second year.					
2 acres of napier mulch					
				£ s d	£ s d
656 days labour	..	..	..	56 1 5	18 13 10
77 hours tractor work	..	..	..	40 8 6	13 9 6
Fertilizers	..	..	..	10 0 9	3 6 11
Pesticides	..	..	..	1 0 0	6 8
Mulch from maize	..	..	..	—	—
Growing costs of coffee, second year in the field ..				107 10 8	35 16 11

The cost of transporting the maize stover has been included, but the material has been given no market value. The cost of maintenance was considerably less than last year's cost of establishment which was £67-9s-7d per acre of coffee and two thirds an acre of napier mulch. The total cost, before coffee can be cropped, is therefore in the region of £103-£104 per acre of coffee including part of the mulching material.

Extract from Report of the Senior Agricultural Chemist

EFFECT OF FERTILIZERS ON YOUNG COFFEE

On the appearance of the leaf scorch on leaves of young coffee, as reported last year, samples of leaf and soil were taken to see if any concentration of nitrogen or salts could be located. The data was as follows:

										% sol. salts in soil		
				N	P	K	Ca	Mg	Ash	0-6	6-12	12-18
Affected leaf	..	..	..	3.45	.09	2.19	1.85	.47	8.7	.14	.13	.12
Green	..	..	..	3.11	.09	2.05	1.87	.46	8.9	.28	.19	.12

It is seen that there is no appreciable difference between the two sets of results which would indicate excessive salt concentration. But the effect of any localized concentration of fertilizer which could have caused root damage would have already disappeared with the start of the rains. As leaf scorch had been also reported even when cattle manure had been used, a pot test was carried out using ammonium sulphate, calcium ammonium nitrate, cattle manure and urea. Rates of application were at 8 oz., and 4 oz. for the first two, half these amounts for urea, and the nitrogen equivalent for the cattle manure. The methods used were (a) full application, (b) split, at three weekly intervals to simulate a broad band application, and (c) a more concentrated application near the stem of the plant. A fourth method (d) included dropping some of the fertilizer on the leaves, during application. Records were kept of the appearance of the plants, and the average of scorched leaves on each plant after one week are shown below:

Application of:—		S/A		CAN		Cattle Manure		Urea		Totals
1. Rate		Full	Half	Full	Half	Full	Half	Full	Half	
2. Method (a) ..	..	4	4	5	4	5	6	4	3	37
(b) ..	..	4	4	5	4	4	8	5	4	40
(c) ..	..	6	3	5	4	5	5	3	2	33
(d) ..	..	6	3	5	3	4	4	3	2	30
TOTALS ..	..	22	14	20	15	18	23	15	11	—

A week later the plants treated with ammonium sulphate and urea, either at the full rate, or near the stem were defoliating completely and dying. This confirms the suggestion of the above figures that the half rate application had less effect. The action of cattle manure is anomalous. After a further two weeks, plants with the full rate of ammonium sulphate and urea, and also those with calcium ammonium nitrate near the stem were dead. Some of those with these fertilizers at half rate were also dying. A further week showed all those treated with urea and ammonium sulphate to be dead, and a rather less number in the calcium ammonium nitrate pots. The lower rate of application indicates that a less intensive dressing is desirable, and confirms the advice given when this problem first arose two years ago that fertilizer should be applied in a wide band away from the stem. The purpose of the pot tests was to see if by following, by periodic leaf analysis, the take-up of the salts, the reason could be found. Unfortunately, transfer to other duties prevented this being done, although preliminary tests showed that the average leaf contained 0.2–0.3 per cent. of ammoniacal N, and 0.15–0.20 per cent. of nitrate nitrogen on a dry weight basis.

However it was possible to carry on with the field application, set out in the same way as the pot tests, and the results of this are described above, in the field section.

LIMING OF COFFEE SOILS

In connection with the *Fusarium* investigation and the possible resistance to be found by growth in less acid soils, a large number of soils were examined from limed and unlimed fertilizer plots. These have, on the whole, confirmed the statement made in last year's report, that however desirable it might be to raise the pH of Nyasaland coffee soils, the practicability of doing so is doubtful. In the Cholo area, soil, the mean pH of which was 5.7 (range 5.2–5.9), decreased in acidity (to pH 7.2) one month after the application of 50 cwt. of lime per acre in January. On the sulphur treated plots the pH decreased by 0.8 of a unit whereas ammonium sulphate produced a decrease of only 0.2. Nitramoncal and urea increased the pH, the latter to a greater extent. This tendency continued throughout March, but by the end of the rains in April,

there was very little difference between the plots, although the pH of the limed plots was about half a unit above the others. This pattern was maintained until November. Subsoil samples were also examined at that time, and these showed very little difference between the treatments, the limed plot showing the highest pH figure and the urea plot the most acid condition. In August, 1961, samples were taken at foot intervals to three feet (i.e. within the main root zone), but no appreciable differences were seen. The same comment can be made about the soils examined in a similar experiment at Bvumbwe. Determination of exchangeable calcium in these soils confirmed that liming had made no practicable difference as far as the condition for deep rooted perennial crops was concerned.

The pH of the soils at various times is summarized below:

TABLE XIV

Treatment Over two Years	Feb. 1960	Mar.	April	November			August, 1961	
				Top	18"	12"	24"	36"
Control ..	6.4	6.4	5.6	6.0	5.5	—	—	—
Sulphur 700 lb. ..	5.8	6.4	5.6	6.0	5.6	5.9	5.3	5.1
Lime 5 tons ..	7.5	7.3	6.2	6.8	5.8	5.8	5.3	5.1
Nitramoncal 1½ tons	6.5	5.9	5.7	6.2	5.6	5.6	5.1	4.9
Amm Sulphate 1½ tons ..	6.3	5.7	5.6	6.0	5.5	6.0	5.3	5.1
Urea ¾ ton ..	7.2	6.2	5.7	6.1	5.5	5.6	4.9	4.9

Extract from Report of the Soil Physicist

(i) SOIL MOISTURE USE OF IRRIGATED COFFEE, BVUMBWE

In April, 1959, three replicate profiles of gypsum blocks were installed at foot intervals to a depth of ten feet under each of the five treatments of the coffee irrigation experiment at Bvumbwe. These are as follows:

1. Control. No irrigation.
2. Irrigate maturing crop only.
3. Irrigate during flowering period only.
4. Irrigate during maturing and flowering.
5. Irrigate monthly as required.

Since then twice-weekly block readings have been taken using a Bouyoucos moisture meter and gravimetric soil moisture determinations have been made regularly to rooting depth on all treatments to calculate the amount of water required for irrigation, and to check on available water use. As far as possible the available soil moisture has not been allowed to fall below three quarters field capacity during the period that the various treatments required irrigation. The profiles have been restored to this moisture level by metering the necessary quantity of water into four foot square basins around the trees.

Changes in moisture status to a depth of seven feet under three of the treatments from the time the blocks were installed are presented graphically in Fig. 1. The effect of the poor dry season rains in 1959 on the non-irrigated treatment are clearly demonstrated and almost certainly account for the much lower yields obtained from this treatment than from any other in the 1960 harvest (see Table XII, p. 145—1959/60 Part II Annual Report). This treatment also illustrates the approximate rooting depth of the coffee at this time, as despite the severe drought conditions very little

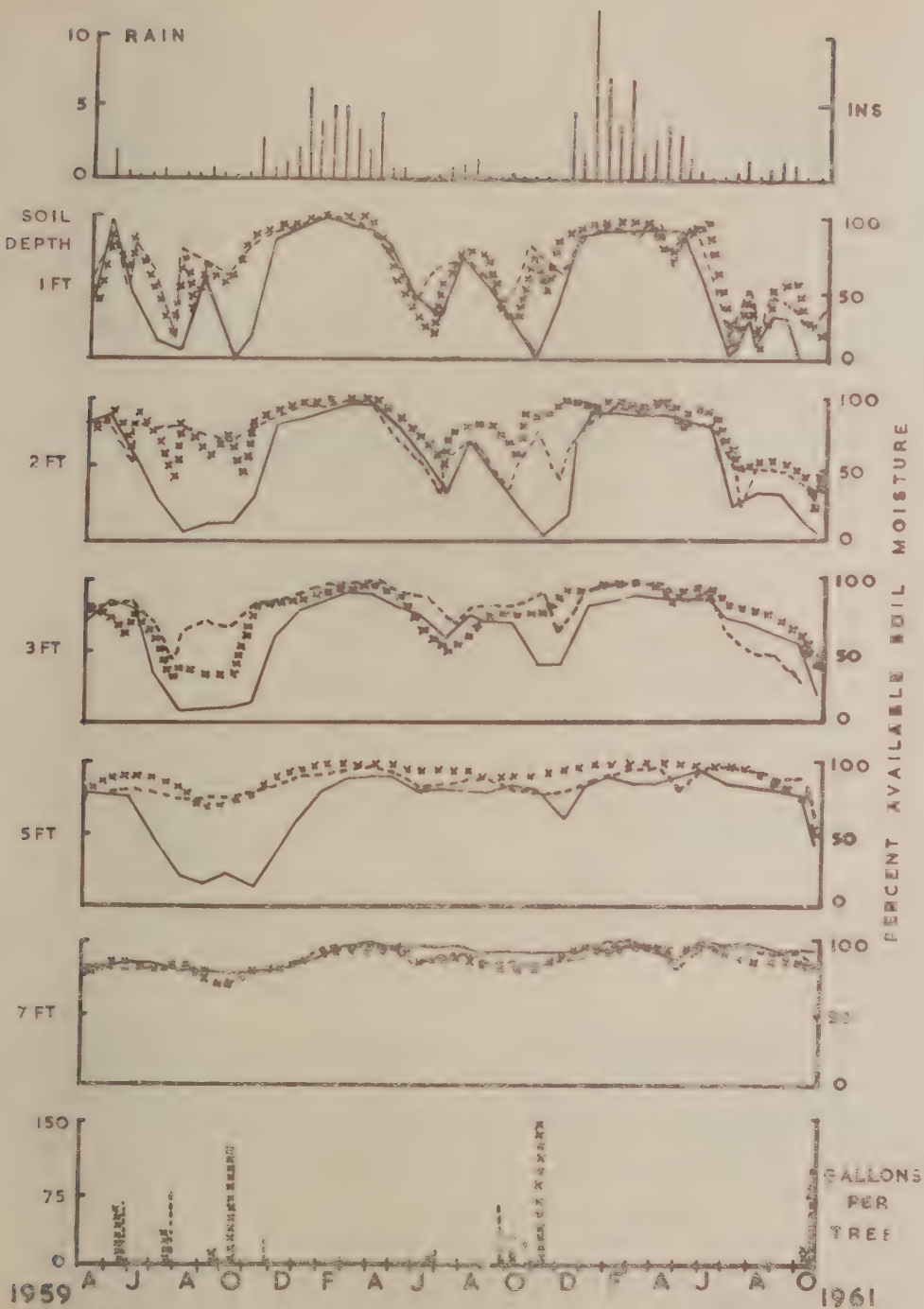


FIG 1. Soil moisture use under three different coffee irrigation treatments, Swumbwe
 No irrigation ——— Irrigate monthly xxxx
 Irrigate maturing and flowering crop - - - -

drying out had occurred at the seven foot depth. This was later confirmed by root washing studies. The effect of irrigation on the other treatments during this period is also noticeable. Somewhat better dry season rains during 1960 and 1961 resulted in less severe drying out in the non-irrigated treatment and delayed the time at which the profile reached wilting point.

(ii) SOIL MOISTURE USE UNDER COFFEE WITH AND WITHOUT INTERPLANTED SHADE TREES

Since 1958 periodic gravimetric soil moisture measurements have been made to check changes in available moisture storage under mulched coffee with and without shade. The three treatments involved have been no shade, and shade from *Grevillea* and *Albizzia*.

Table XV presents changes in inches of available moisture that have occurred under these three treatments, to a depth of seven feet, since 1958, this covering the approximate rooting depth of the coffee.

TABLE XV
Changes in Available Moisture under Mulched Coffee With
and Without Shade to a depth of Seven Feet

Date	Inches of available water		
	No Shade	<i>Grevillea</i>	<i>Albizzia</i>
June, 1958	10.97	10.93	8.23
September, 1958	10.79	7.75	6.16
November, 1958	7.78	5.04	5.01
January, 1959	12.73	9.78	11.34
July, 1959	7.91	7.64	6.05
September, 1959	5.46	3.43	3.82
July, 1960	9.73	8.85	8.85
September, 1960	9.40	5.69	6.36
March, 1961	12.63	11.21	12.30
August, 1961	9.33	9.68	8.97
October, 1961	8.28	5.91	6.33

N.B.—Available water held between field capacity and wilting point in the seven foot profile=11.41 inches.

These figures show that consistently more water has been used under the two shade treatments during the dry season over the past three years when compared with no shade. *Albizzia* would appear to reduce the available moisture to a greater degree than *Grevillea* during the early part of the dry season when the former is still in full leaf, but *Grevillea* which flushes before *Albizzia* then apparently depletes the profile to an equal extent by the end of the dry season. This is in accordance with information obtained from a somewhat similar experiment with tea at Mimosa.

Extract from Report of the Entomologist

Antestiopsis variegata Thunb., the Cameroon Bug, was successfully controlled using Sevin 50 per cent. wettable powder at a rate of 45 gm. in five gallons of water, and this insecticide has shown some promise as an alternative and more efficient control than the use of D.D.T. or malathion although further tests are required before it can be generally recommended. It has less persistence than D.D.T. but showed more rapid action in the field.

Several instances of damage by *Dirphya nigricornis* (Oliver), the Yellow-headed Coffee Borer, were found or reported this season. This species has not been commonly recorded in recent years until this season. However, it is rarely a serious pest and has only occurred in numbers in very limited localities usually on poorly grown coffee. Treatment with dieldrin is recommended as for *Anthonus leuconotus*, the White-headed Coffee Borer.

Parasa vitida (Walk.) was recorded in some areas of Southern Province, but this Nettle Grub caused no damage of economic importance this season. The Gelatine Grub (*Niphaulepis allanta* Karsch.) was found in small numbers in coffee gardens but little damage was done.

FRUIT AND VEGETABLES

1. Banana Manurial Trial, Bvumbwe

A $3 \times 3 \times 2$ N.P.K. manurial trial was described in last year's report.

TABLE I
Yield of Fruit, lb. per acre

	No Phosphate				With Phosphate			
	K_0	K_1	K_2	Mean	K_0	K_1	K_2	Mean
N_0	6,754	12,934	11,601	10,423	11,267	12,934	10,934	11,712
N_1	9,867	11,401	12,467	11,245	13,801	5,400	9,934	9,712
N_2	10,667	9,800	15,067	11,845	15,201	14,467	12,401	14,023
Mean ..	9,089	11,378	13,045		13,423	10,934	11,089	

L.S.D. $p=0.05$, .. 2,468
(between means) $p=0.01$, .. 3,444

There was a significant response to potash only in the absence of phosphate and, because of the high coefficient of variation (35.7 per cent.), the results must be treated with some reserve. A small proportion of fruit was damaged by the cigar end disease, *Stachylidium theobromae*.

2. Pineapple Variety/Manurial Trial

A trial planted at Bvumbwe in April, 1957, at the request of the Cholo African Fruit Gowers' Association, has now been concluded.

Object: To select the best variety for local use and to determine whether the use of fertilizer was justified.

Layout: Two 3×3 Latin squares with double rows, 20 inches apart at 5 feet between centres. Plots of two double rows, $\frac{1}{16}$ th acre in size.

Varieties: 1. Smooth Cayenne or Kew Pine at 18 in. apart.

2. Hawaiian Queen at 12 in. apart.

3. Local Queen at 12 in. apart.

Fertilizer: Sulphate of ammonia at 600 lb. per acre in two split dressings, December and May. To this treatment was added muriate of potash at 150 lb./acre in July.

Results: Results are shown in the table below.

TABLE II
Pineapples, 1958, 61
(Yield, short tons per acre)

Variety	1958/59		1959/60		1960/61		Mean	
	No Ferti-lizer	Ferti-lizer	No Ferti-lizer	Ferti-lizer	No Ferti-lizer	Ferti-lizer	No Ferti-lizer	Ferti-lizer
Smooth Cayenne	7.10	10.70	5.82	13.86	17.14	14.00	10.02	12.85
Hawaiian Queen	0.35	2.68	5.30	8.51	6.85	11.44	4.17	7.54
Local Queen	0.36	1.49	1.87	2.27	2.62	2.95	1.62	2.27
L.S.D. p=0.01	Varie-ties	5.44	Var.	4.34	Var.	2.48	Not Sig.	
	Ferti-lizer	2.09	Fert.	5.57	Fert.	Sig.		
Coeff. of Variation	57%		50%		57%			

Smooth Cayenne was an outstandingly good yielder. There was, however, great variation in plots in the response to fertilizer and this resulted in a high coefficient of variation. The second ratoon crop behaved most erratically. The indications are that significantly higher yields could be obtained in the first two years with fertilizer at the rates employed. Bvumbwe is not a very suitable area for pineapples, the soil being too heavy and the rainfall too high. A certain amount of fruit rotted whilst ripening; *Penicillium* and *Pythium* were isolated.

3. Deciduous Fruit

At Mwera Hill a peach manurial trial was planted in July for the guidance of members of the local Mwera Hill Producers Co-operative, who can find a ready market for fruit in Lilongwe. Little is known of the manurial requirements of peaches in Nyasaland. The soil at Mwera Hill is a slightly acid, sandy clay. The annual addition of sulphate of ammonia appeared to have had little effect in decreasing the pH. Soil analyses have shown that phosphate supplies are reaching the critical limit.

The layout of the experiment is a $3 \times 3 \times 2$ factorial with two replicates. There are three levels of nitrogen, as sulphate of ammonia, and phosphate, as super-phosphate; dung, which is easily obtained, is included as a treatment. The potash supplies are adequate and, as each tree will be mulched with napier which has a high potash content, this treatment has not been included.

4. Variety Observations

Deciduous fruits yielded best at Nchenachena where cool air from the Nyika satisfied the trees' chilling requirements.

Variety					Nchenachena		Mwera Hill		Bumbwe	
					Age	Mean yield, lb. per tree	Age	Mean yield, lb. per tree	Age	Mean yield, lb. per tree
Peach	Angel	..	..	..	11	305	15	98	8	58
	Killiekrankie	..	..	..	11	40	15	60	8	11
	Waldo Improved	..	..	..	11	400	15	90	8	34
Plum	Santa Rosa	..	..	..	11	65	12	34	8	5
	Satsuma	..	..	..	11	83	12	40	8	7

Other promising varieties of peach are *C.O. Smith* and *Hall's Yellow*. Guavas continued to yield well at all stations but no interest was shown in improved varieties. Peaches and plums were badly attacked by fruit fly at Nchenachena and Bvumbwe. Attacks of *Armillaria mellea* on peaches and plums, which are grown on quinine peach rootstocks, have caused so many casualties at Bvumbwe that it is difficult to assess the performance of the trees. The incidence of *Armillaria* is surprising because all indigenous trees were ringbarked and were removed only when dead, before the orchard was planted. The foci of infections are probably roots of trees which were felled before the area was cleared.

A preliminary study of apple rootstocks has been completed at Bvumbwe. The rootstocks which were used included the Malling-Merton Series MM.101-115 and those of the Malling Series M. II, IV, VII, XII, XVI and XXV and Crab C. There were also the Merton Immune 793, a selection from Stellenbosch, South Africa, named A.24 and a local sweetstock from Mwera Hill, Nyasaland, named MH.1. The Malling-Merton Series and 793 are resistant to woolly aphis which already occurs in the Federation.

Two scion varieties were available for budding on the rootstocks, *Blenheim Orange* and *Eickoff Seedling*. *Blenheim Orange* is a variety which has been grown extensively in Central and East Africa, but the fruits are subject to bitter pit. *Eickoff Seedling* is a Rhodesian selection easily distinguishable from *Blenheim Orange* in habit and foliage. Both varieties are fairly tolerant to mild winters.

Due to the mild winter, dormancy of the winter resting buds of the rootstocks was prolonged. This did not affect the production of shoots in the stoolbed which arose, after pruning, from adventitious buds. A reasonable number of shoots was produced after stooling. They tended to be too large in girth at first (i.e. over 10 mm. in diameter) but their size decreased over the years to one more suitable for working as a rootstock. The amount of extension growth was determined by the length of the growing season which, in turn, was determined by rainfall or soil moisture. It was possible to prolong extension growth by irrigation. The propagating qualities of the rootstocks were assessed and this included an assessment of their rooting capacity. The effect of the rootstocks was then assessed on the two scion varieties; data recorded were vigour as measured by girth and extension growth of selected branches, and the first two fruit crops. The most satisfactory rootstocks were those which induced a vigorous tree, i.e. MM.112, MM.114, M. IV and M. XVI. Their propagation qualities were sufficiently good to recommend them for further use.

The symptoms of prolonged dormancy were found only in resting buds and not in the stems or roots, and measures to overcome the phenomenon, by spraying and manipulation, were studied.

It was concluded that stoolbeds and nursery buddings could be managed in the climatic conditions of the Shire Highlands, but the area is not suitable for the production of apples as an economic fruit crop. Adverse factors can, to some extent, be counteracted by the selection of scion varieties with low chilling requirements, by the use of shade to reduce high insolation effects during the dormant season, and by the use of a D.N.C. spray to induce the breaking of dormancy. Acknowledgement is made to the Director, East Malling Research Station, England who provided the planting material.

5. Vegetable Demonstration

A demonstration vegetable garden has been established at Mwera Hill for the benefit of producers of the local Fruit and Vegetable Co-operative. Plots are run on a rotation. Outstanding varieties in yield were *Chantenay* and *Altringham* carrot,

Golden Acre cabbage, *Veitch's Autumn Giant* cauliflower, *Flat Egyptian* beet, *Broad Flag* leek, *Great Lakes* lettuce, Spinach Beet, *Purple Top White Globe* turnip, *Green-feast* pea.

6. Aromatics

Observation plots were established at Bvumbwe of four varieties of mint, *Mentha piperita*, Italian, English and Green mint strains, and *M. viridis*, Spearmint, and of Ninde, *Acolanthus myrianthus*.

COCOA

Makanga

At Makanga observations and data continue to be assembled on the cocoa. The oldest plants are in their fourth year.

(i) PRODUCTION

During the year some trees of most varieties came into bearing though yields were negligible on all but the Amazonian varieties. Full details are given in table I.

TABLE I
Survival and Production of Cocoa Varieties to 30th April, 1961

<i>Variety</i>	<i>Type defined by W.A.C.R.I.</i>	<i>No. trees planted</i>	<i>Percentage trees planted surviving</i>	<i>Percentage of total trees planted bearing</i>	<i>Mean pods per bearing tree</i>	<i>Yield lb. dried beans/acre</i>
T79	Amazonian	24	88	71	23.2	283
T73	Amazonian	42	98	71	12.9	212
T17	Amazonian	18	88	61	17.7	249
T 9	Trinitario	6	100	50	4.3	—
R15	Local Hybrid	15	100	40	6.5	—
NA32 × PA35	Amazonian	18	95	33	8.3	—
WEA2	New Hybrid	12	58	33	3.8	—
S84	Amelonado	24	58	13	10.7	—
A196	Amelonado	15	67	0	0	0
SC4	Local Hybrid	6	100	0	0	0

NOTE: In all but the first three varieties data was inadequate to calculate yields.

A distinct seasonal pattern of production emerged. This is shown in table II and the current year's production is confirming this. The harvest peaks in August and February follow a flush of flower production in the preceding March and September respectively which are months of moderate temperature.

TABLE II
Total pods produced per month (all varieties)

	1960						1961				<i>Total</i>
	<i>J</i>	<i>A</i>	<i>S</i>	<i>O</i>	<i>N</i>	<i>D</i>	<i>J</i>	<i>F</i>	<i>M</i>	<i>A</i>	
Total	17	19	9	—	—	63	223	682	70	43	1,126
Diseased	7	—	—	—	—	46	38	38	32	14	175
% Diseased	41	—	—	—	—	73	17	6	46	32	15.5

At harvest a proportion of pods were found to contain rotten and/or germinated beans sometimes associated with failure to show external ripening symptoms. Table II shows this can be serious at the beginning and end of the harvest period. The variety T73 is particularly susceptible to this condition averaging 22 per cent. damaged pods against 12 per cent. for other varieties. The cause is being investigated by the Pathologist.

(ii) IRRIGATION

The water supplied to the crop is set out below:

			Rain	Irrigation	Total
1/5/60 to 31/10/60	..	..	3.56 in.	38.00	41.56 in.
1/11/60 to 30/4/61	..	..	24.80 in.	8.00	32.80 in.
					74.36 in.

Treatments introducing variations in the irrigation regime have been applied since November, 1960, with a view to ascertaining the water use of the crop, the optimum frequency of irrigation and the value of an induced rest period. Preliminary observations suggest that the crop uses water at a rate of 0.8 x open pan evaporation, that irrigation when the calculated soil moisture deficit reached 4 inches is sufficiently frequent.

(iii) FERMENTATION

The quantities of beans harvested at any one time have not yet been sufficient for a proper commercial scale fermentation. Some progress has been made with a small scale process. A wooden box 9 in. x 6 in. x 6 in. deep, with a perforated false bottom and drip tray to collect the sweatings, has been made to fit a thermostically controlled oven which is used to supplement the naturally produced heat of fermentation. The best results have been obtained with 2 days at 35° to 40°C for the initial aerobic phase followed by 2 days at 45° to 50°C for the anaerobic phase with daily turning throughout. The beans have been mainly shade dried with periods of sun drying increasing from 2 to 6 hours daily over 4 days. 11 batches have been fermented.

The out turn of dry beans from wet beans averaged 34.6 per cent. which is a little low even for Amazonian types. The mean bean weight of the batches fermented has varied from 1.10 grams to 0.52 grams averaging 0.73 grams. This is too low to be satisfactory: 1 gram is a good average.

(v) PESTS AND DISEASES

The general condition of the trees was somewhat healthier than the previous year. Abnormal leaf conditions did not develop to any marked extent.

Leaves whitened, and even scorched by the sun were found on many trees, but not so seriously as to warrant shade.

Leaf damage by sundry insects occurred, particularly the mango weevil, but not severely. Extensive mechanical damage was done by strong winds at the beginning of the rains particularly on heavily bearing trees.

Extract from Report of the Plant Pathologist

Cacao. During the harvest period December, 1960, to April, 1961, large numbers of diseased pods were noticed on the experimental plot at Makanga. The following table shows the amount of diseased pods harvested during the period compared with the total numbers.

TABLE

Pods	Dec '60	Jan '61	Feb '61	March '61	April '61	Totals
Harvested	63	223	682	70	43	1,081
Diseased	46	38	38	32	14	168
% diseased ..	73	17	6	46	32	16

There were two distinct types of disease. The first was a definite pod rot, either a dark brown to black dry rot, or a lighter brown rot which only occasionally infested the whole pod. With these were associated *Botryodiplodia theobromae* Pat and conidial *Glomerella cingulata* (Stonem) Spauld and Schrenk respectively. The second type of disease was not readily visible externally, except as an abnormally long retention of the green colour of unripe pods. On opening the pods, the beans were found to have germinated. Occasionally associated with this condition, and also with a light brown pod rot, was *Fusarium sambucinum* Fuckel.

An inoculation trial was carried out using these three fungi, and some others also associated with rotted pods. To date the results are not complete, but preliminary indications are that the germination of beans in the pods may be physiological, with fungi only secondarily associated.

Extract from Report of the Entomologist

The insects recorded as attacking cocoa in last season's Annual Report (p. 157) all occurred again during this season but there was no serious outbreak of any pest. A number of other insect pests have been discovered damaging parts of the plant including a *Helopeltis* sp., *Anoplocnemis curvipes* and a number of Homoptera at present unidentified. An *Empoasca* sp. was found attacking cocoa leaves at Masanjere. Damage was not assessed but considerable leaf curl and some yellowing was noticed that was attributed to this and/or other Cicadellidae present. A smaller amount of similar damage was found at Makanga.

Earias biplaga (the Spiny Bollworm of cotton) was recorded as tip-boring young cocoa plants on Makanga Experiment Station. In one or two cases severe damage was done to branches, the damage being very similar to that caused by the same insect on cotton. The close proximity of cotton and a number of other hosts to the cocoa plot may account for this attack on a crop not normally associated with Spiny Bollworm. The larvae were bred in Zomba.

PASTURES

1. Fertilizer Experiment on Permanent Pasture

Location: Bvumbwe, on a very poor sandy soil overlying laterite.

Object: To assess the effect of three kinds of nitrogenous fertilizers with and without phosphate, sulphur and lime on a permanent pasture of star grass (*Cynodon plectostachyum*) mixed with some Rhodes grass (*Chloris gayana*) and Panicum (*Panicum coloratum* var *makarikariense*). The experiment, a randomized block layout, was reported fully last year and the fourth year's results are recorded in the table below.

TABLE I
Fertilizer Experiment on a Permanent Pasture

Treatment							Bvumbwe 1961 Dry Matter lb./acre
1. Control (Nil)	..	..	..	..	..	..	1,246
2. Sulphate of ammonia, 400 lb./acre	..	..	..	..	..	..	2,040
3. 2+ Dolomite 845 lb./acre	..	..	..	..	..	..	1,920
4. Sulphate of ammonia, 800 lb./acre	..	..	..	..	..	..	4,128
5. 4+ Dolomite, 845 lb./acre	..	..	..	..	..	..	2,994
6. Nitramoncal, 800 lb./acre	..	..	..	..	..	..	3,245
7. 6+ Gypsum, 1,000 lb./acre	..	..	..	..	..	..	2,487
8. Urea 46 per cent., 175 lb./acre	..	..	..	..	..	..	2,409
9. Urea, 350 lb./acre	..	..	..	..	..	..	3,098
10. 9+ Single superphosphate, 440 lb./acre	..	..	..	..	..	..	3,431
11. 9+ Triple supers, 175 lb./acre	..	..	..	..	..	..	3,141
12. 9+ Gypsum, 1,000 lb./acre	..	..	..	..	..	..	3,509
Mean	..	..	..	..	..	..	2,804
L.S.D. $p=0.05$	..	..	..	..	..	..	1,169
$p=0.01$	..	..	..	..	..	..	1,575
Coeff. of variation	..	..	..	..	..	..	28.9%

Results did not differ materially from last year's. Sulphate of ammonia continued to obtain the greatest response, and liming reduced the yield. Gypsum tends to enhance the effect of urea, but it is not clear whether sulphur or calcium is the important factor. The crude protein content of the pastures increased from 6.1 per cent. for unfertilized plots to 6.9 or 7.0 per cent. on plots 4, 6 and 9 where the high rates of nitrogenous fertilizer were applied.

Records were taken when most of the plots in a block were ready for grazing. Two blocks were then mown and the grass removed for silage or hay. The other two blocks were grazed and it was possible, by taking two samples, to estimate the amount of grass eaten. The table shows the total yield of grass produced in three cuts taken in January, March and May.

The variation in the plant population was checked throughout the growing season. The unfertilized plots were the weediest and contained only 21-29 per cent. of planted grasses. The main weeds were *Sporobolus*, *Rhynchelytrum* and *Cyperus*. The best sward was produced by the high rate of sulphate of ammonia; urea encouraged Rhodes grass.

The stocking rate of a fertilized pasture of this nature was 1.4 acres per head in 1961.

2. Grass/Legume Experiment

Location: Bvumbwe.

Object: To assess comparative productivity of a grass when interplanted with a legume and when treated with a nitrogenous fertilizer.

The experiment, a 2⁴ factorial design, was described fully last year. Three cuts were taken during the rains, the *Cenchrus Makarikari* mixture being ready in January, February and April and the Rhodes grass in February, April and May. During the dry season the plots were topped, but no green matter was recovered and it was not recorded as grazing material.

Treatments:

G1. Mpwapwa strain of Rhodes grass (*Chloris gayana*)

G2. Mixture of African foxtail (*Cenchrus ciliaris*, Grasslands strain) and Panicum (*P. coloratum*, Nachingwea strain).

N=400 lb. per acre sulphate of ammonia in two split dressings.

D=*Desmodium intortum*

S=*Stylosanthes gracilis*.

TABLE II
Grass/Legume Experiment, Bvumbwe
(Dry Matter, lb./acre)
Legume

Treatment	No legume	Legume			Mean
		D	S	D+S	
G1. Rhodes Grass without N.	2,131	2,788	2,939	2,503	2,590
Rhodes Grass with N.	3,513	2,601	4,136	4,155	3,601
G2. <i>Cenchrus</i> , etc. without N.	3,373	3,971	4,166	3,736	3,812
<i>Cenchrus</i> , etc. with N.	3,711	3,645	4,849	4,970	4,294
	3,182	3,251	4,023	3,841	---
L.S.D. P= 0.05	1,319				
0.01	1,831				

The response to treatments was less than last year's. Significant increases in yield were obtained only in the case of Rhodes grass, with sulphate of ammonia at the rate of 400 lb./acre in two split applications, and with *Stylosanthes* and nitrogen; in the case of the *Cenchrus Makarikari* mixture, the *Stylosanthes* and nitrogen treatment was the only one which resulted in a significant increase of dry matter. There was little, if any, effect due to *Desmodium*.

The plant population varied throughout the season. Makarikari was swamped by the *Cenchrus* and the legumes, when present, during the rains but provided a higher proportion of the green matter in the dry season. *Desmodium* was best at the end of the rainy season and, although it had a very deep root system, did not recover rapidly after a long dry season; Rhodes grass, when fertilized, quickly swamped the *Desmodium* which died out. *Desmodium* survived better in the less aggressive *Cenchrus* mixture; it would probably grow best as a pure stand crop as for lucerne. *Stylosanthes* displayed a greater resistance to drought and gave a much more balanced growth throughout the year. *Cenchrus* is obviously a grass of which much greater use could be made and, when mixed with *Stylosanthes*, produces the most satisfactory legume mixture which has yet been grown at Bvumbwe.

The protein content of the dry matter increased from about 7.8 per cent. crude protein (on a dry weight basis) for pure stand grass plots to about 10.1 per cent. when legumes were included. The protein content of the *Cenchrus* mixture increased both with nitrogenous fertilizer and in the presence of *Desmodium* and *Stylosanthes*.

TABLE III
Protein Content of Grass during the Growing Season

	Per cent. Crude Protein		
	No Fertilizer	Nitrogenous Fertilizer	In presence of <i>Desmodium</i> and <i>Stylosanthes</i>
Rhodes	5.7	6.0	6.4
<i>Cenchrus</i> /Makarikari	7.8	8.3	8.9

3. Variety Observation Plots

Small plots of grasses and legumes, 1/80 acre in size, have been recorded over the last three years. The object is to select the most outstanding varieties with a view to introducing them in leys or permanent pastures of the mixed farm or using them for mulching material in coffee. Due to shortage of staff, it has not yet been possible to go on to the next step—the planting of a formal variety trial.

The plots include varieties of the following species of grass which are worth recording:

Acroceras macrum (nile), *Brachiaria brizantha*, *B. decumbens*, *B. ruziziensis*, *Cenchrus ciliaris* (foxtail), *Chloris gayana* (rhodes), *Digitaria decumbens* (pongola), *D. diversinervis*, *Echinochloa pyramidalis* (antelope), *Eragrostis curvula* (love-grass), *Melinis minutiflora* (molasses), *Panicum coloratum* (makarikari), *P. maximum* (guinea), *Paspalum dilatatum*, *P. nicorae*, *P. notatum* (bahia), *P. urvillei* (=virgatum), *Pennisetum clandestinum* (kikuyu), *P. purpureum* (napier), *Phalaris tuberosa* × *arundinacea* (rompha), *Setaria kasungula*; and the following species of legume: *Aeschynomene americana*, *A. repens*, *Centrosema pubescens*, *Desmodium discolor* (horse marmalade), *D. intortum* (fiji clover), *D. salicifolium*, *D. uncinatum*, *Glycine javanica*, *Listia heterophylla*, *Stylosanthes gracilis*, *Vicia villosa*.

Of these, the plants listed below are outstanding and are worth comparing with those normally recommended and used in trials 1 and 2 above.

Echinochloa pyramidalis, Antelope grass. Once established at a 3 ft. × 18 in. spacing, *Echinochloa* has given very high yields of green matter. When cut in February at the height of ten feet, the equivalent of 20 to 30 tons has been measured. Because the stems are not very thick, it is a grass which can be cut by a mower without damage and is very suitable for use as a coffee mulch. There are several varieties which would be useful as a fodder grass but are not as high yielding, giving in the region of ten tons per acre with a main cut in February and a second small cut in July. If cut before flowering, the leaves contain 13.1 to 13.3 per cent. crude protein and the stems 6.1 to 7.7 per cent. The *Chirundu* strain is upright, similar to the type species but not as vigorous as Bvumbwe. *Parfuri* is a creeping form and is preferable to *Devuli*. All these varieties are vegetatively propagated.

Pennisetum purpureum, Napier grass. The *Gold Coast* and *Uganda* forms are preferable to the *Local* for use as coffee mulch and in leys for silage. *Uganda* comes into flower before *Gold Coast* and produces slightly less green matter. *Uganda* is

slightly easier to handle for mulching material because it is hairless. Six to ten tons per acre of green matter are produced at a cut, when required for fodder, and two such cuts, plus a third smaller cut are produced in a year.

Melinis minutiflora, Molasses grass. Very useful as a pioneer of overworked land, molasses has produced high yields in the first two years after sowing. A peak yield of 16 tons green matter per acre in February and 8 tons in August was produced but this rapidly fell to 10 tons and $\frac{1}{2}$ ton respectively in the following year. It could be used as a nurse for a longer-term grass such as Rhodes. Protein content was 6.3 per cent.

Brachiaria. Three species *Bb. brizantha*, *decumbens* and *ruziziensis*, are under trial. Of these *B. decumbens* is the most promising, producing 13 tons of green matter per acre. Protein content of all species, at the time of cutting, was 7.1 per cent.

Panicum coloratum. The creeping form *makarikariense* has been planted for the green bite it produces in the dry season. The *Nachingwea* form roots more rapidly at the node and provides a better cover. Protein content of the stems and leaves, just before flower spikes appeared was 5.6–5.7 per cent.

Panicum maximum, Guinea grass. Although not a creeping grass, the Sabi form is a high yielder and could be used in a permanent pasture. Being clumpy it could be intersown with *Stylosanthes* or *Desmodium*.

Extract from Report of the Senior Agricultural Chemist

PASTURES

1. PASTURE COMPOSITION IN RAINS

34 grasses and legumes from Bvumbwe were examined for protein content in the rains (February) and the data is summarized below, in groups (on a dry matter basis).

20 per cent. *Lucerne Rhizoma*, *Trifolium johnstonii*.

15–20 per cent. *Desmodium intortum*.

10–15 per cent. *Cynodon dactylon*, *Echinochloa parviflora*, and *Phalaris tuberosa* *orundinalis* (Rompha), *Echinochloa pyramidalis*.

7–10 per cent. *Desmodium uncinatum*, *Paspalum notatum* (*pensacola*), *Pennisetum Purpureum* (Uganda).

5–7 per cent. *Brachiaria brizantha*, *Cenchrus ciliaris*, *Brachiaria decumbens*, *Chloris gayana* (*Mpwapwa* and *Rongai*), *Echinochloa chirundu*, *Eragrostis curvula* (Ermelo), *Echinochloa devuli*, *Melinis minutiflora*, *Panicum bambatsi*, *Makarikari minutiflora* (Nachingwea), *Paspalum dilatatum*, *nicorae*, *notatum* (Paraguay), *P. urvillei*, *Pennisetum clandestinum*, *Setaria kasungula*.

3–5 per cent. *Acroceras macrum*, *Chloris gayana* (Katambora), *Digitaria decumbens*, *Panicum maximum* (Sabi).

2. Poor spreading and growth of Makarikari on a Mlanje estate was examined, and provided one of the few occasions when leaf analysis has not provided a solution to the problem. Samples from poor and better growing areas were compared with those from good Makarikari growing at Bvumbwe. No differences of significance were noted, but the range of data for micronutrients is recorded for reference.

Al	B	Cu	Fe	Mn	Zn
190–520	28–35	3.9–4.8	130–310	200–580	16–23 ppm

3. The related subject of silage may also be included here. Maize initially containing 9.6 per cent. protein, had this figure decreased to 4.1 per cent. seven months after ensiling.

ROTATION EXPERIMENTS

1. TIME OF PLOUGHING RHODES GRASS LEYS

At Chitedze Rhodes grass was ploughed out on three dates early in 1960 and yields of maize, with and without sulphate of ammonia, and of groundnuts grown on these plots in 1960/61 was compared with similar crops grown as the second arable break of the rotation on the plots ploughed out in early 1959. The design was a randomized block with plots split for presence and absence of fertilizer. There were four replications of the plots ploughed in 1960 and twelve replications of those ploughed in 1959.

TABLE I

Effect of time of ploughing of Rhodes grass on following maize and groundnuts
Variety: *Mthenga* Yields: lb./acre grain

Treatment	Maize		Groundnuts	
	Ploughed 1959	Ploughed 1960	Ploughed 1959	Ploughed 1960
P ₁ Early ploughed 10/2/59 and 25/2/60	4,800	5,380*	1,200	1,070
P ₂ Intermediate 24/2/59 and 19/3/60	4,670	4,700	1,180	1,010
P ₃ Late ploughed 25/3/59 and 14/4/60	4,770	4,210	1,240	1,130
L.S.D. 5%	260	840	70	180
O—No fertilizer applied	4,290	4,480	1,190	—
N—200 lb. S/A applied	5,200***	5,050	1,210†	—
L.S.D. 5%	210	685	60	—
Mean	4,740	4,760	1,210	1,070
Coef. Varn.	13.6%	16.5%	9.4%	9.7%
Maize after Maize	4,320	†Residual effect of S/A applied to previous maize crop.		
Maize after Groundnuts	5,170***			

There was this year a marked response, by maize only, to early ploughing, as the dates were spread more widely than last year. There was a marked response to nitrogen applied to maize in the second arable year. The overall response in the year after ploughing was smaller, but the response from individual times of ploughing increased from a mere 4 per cent. at the early ploughing to 20 per cent. at the late ploughing. Maize grown in the second arable year after groundnuts did very much better than maize following maize.

2. CONTINUOUS CULTIVATION PLOTS—CHITEDZE

The ox, tractor and hand cultivated plots were in their fourth season, the first crop of the second three year cycle. The rotation is groundnuts, tobacco, maize and there was a heavy eelworm infestation where tobacco was being grown for the second time in four years. The effects were most marked in the unfertilized plots, while the fertilized plots, though having well knotted roots, produced a vigorous crop with a reasonable yield.

TABLE II

Yields from continuous cultivation plots, A. South, Chitedze

Varieties: Namlenga or Askari, Mwitunde and Dark Fired Yields: lb./acre saleable produce

Treatment		1957/58	1958/59	1959/60	1960/61
Hand cultivated	AO ..	Mz. 1,000	G.N. 1,350	Tob. 930(21.2)	Mz. 3,380
	F ..	2,770	1,300	1,200(21.5)	4,690
	BO ..	G.N. 1,010	Tob. 850(47.8)	Mz. 3,710	G.N. 960
	F ..	—	1,120(46.0)	3,980	970
	CO ..	Tob. 540(38.8)	Mz. 3,160	G.N. 1,030	Tob. 760(36.0)
	F ..	1,030(41.3)	4,380	1,060	1,130(42.5)
Ox cultivated	AO ..	Mz. 2,660	G.N. 1,220	Tob. 390(15.1)	Mz. 2,300
	F ..	2,960	1,090	960(19.0)	3,750
	BO ..	G.N. 920	Tob. 570(32.6)	Mz. 3,220	G.N. 940
	F ..	—	1,000(36.9)	3,680	980
	CO ..	Tob. 600(56.5)	Mz. 3,400	G.N. 740	Tob. 280(22.4)
	F ..	930(55.0)	4,010	630	1,010(33.9)
Tractor Cultivated	AO ..	Mz. 2,380	G.N. 1,400	Tob. 690(17.5)	Mz. 2,890
	F ..	2,960	1,370	1,320(23.6)	4,330
	BO ..	G.N. 890	Tob. 670(36.1)	Mz. 3,800	G.N. 1,100
	F ..	—	1,100(43.5)	3,660	1,110
	CO ..	Tob. 460(39.4)	Mz. 3,280	G.N. 1,130	Tob. 330(25.9)
	F ..	1,100(50.0)	4,760	1,100	1,230(34.7)
F=		200 lb. S/A on on Mz. 200 lb. C+100 lb. S/A on Tobacco	200 lb. S/A on on Mz. 200 lb. C+100 lb. S/A on Tobacco	200 lb. 25/10/0 on Mz. 200 lb. C+100 lb. S/A on Tobacco	200 lb. 25/10/0 on Mz. 200 lb. C+100 lb. S/A on Tobacco

N.B. Figures in brackets are grade index of tobacco.

Apart from the danger of eelworm infestation, this rotation appears to be maintaining yields well, especially where fertilizer is applied. The soil is brown sandy clay loam of the Kandiani series.

3. OCTOBER PREPARATION OF GARDENS TRIALS

These trials were randomized blocks of seven treatments with four replicates and are laid down at Chitedze on Class I red brown sandy clay loam of Ngongonda series and at Tuchila on Class IVw grey sandy loam over clay. The experiment at Tuchila is being wound up so results are summarized here of both experiments. The experiments were continuously cropped with maize.

TABLE III
Effects of method of October preparation of maize gardens
Variety: Namlenga *Yields: lb./acre grain*

<i>Treatments</i>	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	<i>Mean</i>
<i>Tuchila</i>	<i>No fert.</i>	<i>No fert.</i>	<i>No fert.</i>	200 lb. S/A	200 lb. S/A	200 lb. S/A	
1. Split ridges— Bury trash ..	2,260	2,100	2,330***	2,650*	1,910***	3,410*	2,440
2. Split ridges— Burn trash ..	3,220	1,730	2,100**	3,200***	1,920***	3,210*	2,560
3. Split ridges— Mulch trash ..	2,300	1,850	2,170**	2,650*	1,600**	3,450*	2,340
4. Split ridges— Remove trash ..	2,540	1,840	1,800*	2,540*	1,550*	2,720	2,170
5. Make up ridges— Burn trash ..	2,700	1,640	1,540	2,930*	1,360*	2,240	2,070
6. Make up ridges— Mulch trash ..	2,150	1,340	1,770*	2,490*	980	2,680	1,900
7. Make up ridges— Remove trash ..	2,330	1,750	1,310	1,900	710	2,590	1,760
Mean split ridges (2, 3, 4) ..	2,690	1,810	2,040*	2,800*	1,750**	3,130*	2,370
Mean make up ridges	2,390	1,670	1,540	2,440	1,020	2,500	1,910
L.S.D. 5% 1-7 ..	740	470	460	590	540	790	—
Mean ..	2,500	1,750	1,870	2,620	1,430	2,900	2,180
Coef. Varn. ..	20.0%	20.8%	16.2%	14.9%	25.6%	18.3%	—
<i>Chitedze</i>	<i>No fert.</i>	<i>No fert.</i>	<i>No fert.</i>	200 lb. S/A	<i>No fert.</i>	200 lb. S/A	
1. Split ridges— Bury trash ..	3,300	2,770*	1,920*	2,850**	2,080**	2,610	2,590
2. Split ridges— Burn trash ..	3,890	2,800*	2,240**	2,890**	2,050**	2,470	2,720
3. Split ridges— Mulch trash ..	2,760	2,240	1,720	2,570*	1,860*	2,330	2,250
4. Split ridges— Remove trash ..	2,810	2,400	1,480	2,330	1,630	1,990	2,110
5. Make up ridges— Burn trash ..	3,200	3,370**	1,650	2,290	1,460	2,560	2,420
6. Make up ridges— Mulch trash ..	3,150	2,390	1,470	2,310	1,380	2,620	2,220
7. Make up ridges— Remove trash ..	2,960	2,690	1,500	2,060	1,340	2,060	2,100
Mean split ridges ..	3,160	2,480	1,820*	2,600**	1,910**	2,220	2,360
Mean make up ridges	3,100	2,810	1,540	2,220	1,390	2,370	2,240
L.S.D. 5% 1-7 ..	930	530	380	420	500	490	—
Mean ..	3,150	2,660	1,710	2,470	1,690	2,330	2,330
Coef. Varn. ..	19.9%	13.4%	12.5%	11.4%	20.0%	20.1%	—

It is interesting to note the differences between the two sites. On the alluvial soil at Tuchila, moderate yields are maintained fairly well, and split ridge cultivation gives on average about two bags of grain per acre more than remade ridges. On the red ferallitic soils at Chitedze there is a decline in yield potential which starts well above and ends below that of Tuchila, and there is much less difference between split and made up ridges. It appears that trash and stover should be burned or buried, whichever is most convenient, unless it can be carted off and returned as really good farm-yard manure.

4. CONTINUOUS CULTIVATION PLOTS

The acre blocks of maize at the four main stations continue to give maintained or increased yields under good farming practice. The position for cotton is not good however, and that for groundnuts unresolved. Figures to date are given below.

TABLE IV
Continuous cropping plots

Variety: See below

Yields: lb./acre saleable produce

Year	Chitedze	Chitala			Mbawa			Tuchila
	Maize	Maize	Maize/ Cotton	Cotton	Maize	Mz./G.N. Rotation		Maize
						Maize	G-nuts	
1955/56	2,880	—	—	—	—	—	—	—
1956/57	Not planted	Exhaustion plots to 1958			2,000	—	—	—
1957/58	3,000	340	750M.	60	2,530	—	—	2,010
1958/59	3,080	2,300	460C.	330	2,780	—	—	3,100
1959/60	2,224	2,180	3,430M.	130	3,400	5,820	1,380	2,070
1960/61	2,900	3,700	200C.	70	4,350	6,370	1,000	4,620
Fertilizer applied per acre per annum	200 lb.: S/A and 250 lb. Supers. 5 tons of F.Y.M. since 59/60	200 lb.: S/A and 5 tons F.Y.M. since 1958/59	200 lb.: S/A and 5 tons F.Y.M. since 1958/59	200 lb.: S/A and 5 tons F.Y.M. since 1958/59	200 lb.: S/A and 125 lb. Supers. 5 tons F.Y.M.	c. 150 lb. P. S/A and 5 tons F.Y.M.	125 lb. Supers.	200 lb. S/A
Variety	Namlenga	Mlonda	Mlonda and A.637.	A.637.	Local	Askari	Dixie Runner	Na- mlenga
Soil	Red Br. S.C.L. Lilongwe Series	Grey Brown Clay			Red Brown S.C.L./S.L. Loudon Series			Brown S.L. Class II/ III red ferallitic

Rotations: Continuous Cropping of Maize

Location: Bvumbwe.

Object: To observe the effect of continuous maize cropping at three nitrogen fertilizer levels.

This experiment was reported in last year's Report (q.v.) and a third crop has been harvested. The maize trash is ploughed in annually. For the first time there was a significant increase in yield to a rate of fertilizer exceeding 250 lb. per acre. A demand is now being created for higher fertilizer rates but a level of 600 lb./acre is not yet justified.

Continuous Cropping of Maize, Evumbwe

<i>Treatment</i>	<i>Yield shelled maize lb. per acre</i>	
	1961	Mean 1959-61
Sulphate of ammonia, 250 lb./acre	3,085	3,305
Sulphate of ammonia, 400 lb./acre	4,159	3,889
Sulphate of ammonia, 600 lb./acre	3,655	3,527
L.S.D. $P=0.05$	629	—
$P=0.01$	873	—
Coeff. of Variation	16%	—

Makanga

The rotation and continuous cropping trials at Makanga, details of which were given in the 1960/61 report (Part II, pages 64 and 65), were cropped for the 4th year. Yields were reasonable for all three crops. No loss in yield has yet been detected as a result of monocropping with maize or cotton, or excluding groundnuts from the standard 3 course rotation groundnuts/maize/cotton. The introduction of a three year bush fallow period and application of FYM has not increased yields.

Exhaustion plots were maintained for maize and cotton.

MIXED FARM UNIT, BVUMBWE

The pig section of this Unit has been abolished because it was unprofitable. The pedigree Jersey herd has been increased in its place and the number of milking cows and heifers has risen from 22 to 32. The stocking rate of the 100-acre farm, comprising 24 acres of arable, 32 acres of ley and 44 acres of permanent pasture, has improved and one cow equivalent is now maintained on 2.1 acres in place of 2.6 acres in the previous year. This could be compared with the figure of 1.4 obtained for the fertilizer experiment on permanent pasture at Bvumbwe. The stocking rate is determined by the amount of silage which is available to maintain the stock throughout the dry season and, with a herd of 51 beasts, or 47.5 cow equivalents, there is still a surplus. The stage has not yet been reached where it is necessary to cull because, although there are several low yielders, there would be no saving by disposing of them. The calving index, the interval between the two calvings immediately preceding the lactation was, for an average of 17 cows, 370.5 for the period July, 1960, to June, 1961.

Some bull calves, instead of being slaughtered at birth, were reared mainly on skim milk for veal. It was not a profitable proposition. Vealers nine weeks old and weighing 75 lb. cold dressed weight fetched only 1s-3d per lb. and realized only a shilling or so above the cost of producing them.

During the heavy rains of January and February, milking cows suffered a setback from an attack of streptothricosis. There was also a high incidence of liver fluke and more frequent dosing was necessary. Some cases of mastitis appeared for the first time.

TABLE I
Bvumbwe Jersey Herd, Milk Yields, 1960/61

<i>Number of Cows</i>					<i>Mean production (lb.)</i>
4 in their fourth lactation*	..	..	..	..	8,506
5 " " third "	..	..	..	..	7,665
3 " " first "	..	..	..	..	5,733
5 " " second "	..	..	..	..	5,296
17 Mean, all lactations	..	..	..	..	<u>6,800</u>

* 300-day lactation.

The total milk produced was 12,717 gallons or 127 gallons per acre. This acreage includes all arable land on which most of the concentrates are produced. The cost of the milk was 23.5 pence per gallon not including overheads of which the total cost of feed was 13.5 pence. The cost was slightly higher than last year owing to the need for more intensive hygiene.

Detailed costs of production are not published in this report because it is very difficult to simulate a commercial business in an investigational unit of this size. The demonstration of profit or loss under these conditions is not the most important objective. The records have been drawn up to emphasize the relationship between physical input and physical output which can then be interpreted in terms of money-values in prevailing economic circumstances. This avoids argument about the validity of the estimated costs and prices used. If a farmer knows his own labour and

tractor costs and wishes to disregard overheads when comparing his methods with those applied at Bvumbwe, he should use the figures which apply to his own circumstances and not those applying to Bvumbwe. The production of an acre of maize at Bvumbwe is shown in Table II below as an example.

TABLE II
Production of One Acre of Maize, Bvumbwe, 1961

<i>Physical Input</i>	<i>Rate</i>	<i>Estimate, Costs and Returns 1960/61</i>		
		£	s	d
1 acre of land	—	—	—	—
19.1 tractor hours work	10s-6d	10	0	3
119.1 labour days	1/5½ to 1/8	10	0	6
350 lb. Fertilizer	38s-0d per 200 lb.	2	19	2
35 lb. hybrid seed	—	0	7	5
Insecticide (D.D.T.)	—	0	6	7
Total cost	—	23	13	11
Output 25.04 bags	30s-0d per bag	37	15	1
„ Margin of Profit	—	£14	1	2

The cost of production of 25.04 bags is £23-13s-11d or 18s-11d per bag, not including overheads, which is only slightly higher than shown in previous years (see last year's Report). If the maize is valued at 30s per bag, the replacement cost, there is a reasonable margin of profit to cover overhead costs. The above table shows 119 labour days per acre for maize which is high when compared with a similar unit at Chipinga in Southern Rhodesia where only 24 labour days are employed. Possible reasons for the disparity are planting by hand, more prolonged rainfall at Bvumbwe, necessitating cultivations at a later stage in the growth of the crop and extra work involved in growing the crop on ridges.

Chitedze Unit Farm

1960/61 was the second season in which the farm was worked as a Unit, with all its fields in operation. This season all buildings were ready for use.

The holding consists of 20 acres comprising nine two acre rotation fields farmed on a five arable-four ley rotation, one acre of elephant grass and one acre of buildings, trees etc. Buildings comprise one house, two huts for labourers, one *khola*, one *ukhokwe* and ten tobacco barns. A plough, a ridger, a stripped-down ridger used as a cultivator, and a cart are used on the farm, and two good oxen are maintained to draw these.

All the fields of the farm have been fenced so that changes in management can be effected without trouble and so that some measure of rotational grazing can be achieved. The farm is still only half tamed, but the past season's working was promising enough to enable the farmer to embark on his own this coming season with £120 working capital in the Post Office Savings Bank. The farmer and two men, now young relatives of the farmer, work the unit. In the past two years it was run by one skilled and two unskilled labourers paid from station votes.

The soil is a deep red brown sandy clay loam of the Ngongonda series.

A summary of the crops produced in the last two years is given below.

TABLE I
Summary of Crops produced at Unit Holding, Chitedze
(All figures per acre unless otherwise stated)

Crop and Variety	Year	Acreage	Yield/acre lb. seed or leaf	Valued or sold at: £ s d	Cash spent fert. or seed £ s d	Net return for Labour £ s d	Labour input man-days	Return as labour d./man-day
Tobacco	1960	1.7	475	10 8 0	2 4 0	7 19 0	203	9.4d
Dark fired ..	1961	2.7	525	25 9 6	1 17 0	23 12 6	155	36.6d
Groundnuts, Mwitunde ..	1960	1.45	650 (800) Some kept for seed	13 11 3	Nil	13 11 3	177	18.4d
Dixie Runner ..	1960	1.26	655 (990) Some kept for seed	14 5 9	Nil	14 5 9	181	18.9d
Mwitunde and Dixie Runner	1961	2.37	505 (680) Some kept for seed <i>In shell</i>	6 6 6 <i>Sold in shell</i>	Nil	6 6 6	84 No labour for shelling	18.00d
Maize, Namlenga	1960	Figures	in brackets are the	estimated	total yield	per acre		
Askari ..	1960	1.7	2,820	11 15 0	Nil	11 15 0	47	60.0d
Undersown with rhodes	1960	2.0	2,200	9 3 6	0 18 9	8 4 9	88	58.0d
Askari ..	1961	1.72	4,000	16 13 4	Nil	16 13 4	42	95.0d
Askari ..	1961	1.72	3,200	13 6 8	Nil	13 6 8	45	71.0d
Undersown with rhodes		grass					Ploughed by tractor	

N.B. The 1960 tobacco crop was very poor quality and the 1961 groundnut crop suffered low yields as a result of late weed growth, which could not be removed during tobacco curing.

As the African farmer has as yet nothing that can really be costed as an overhead, the crops have been valued in terms of net cash return per acre (i.e. money received for the crop sold less cash spent on necessary items which cannot be made on the farm, e.g. fertilizer), labour put into the crop and resulting cash return for the labour involved.

It will be seen that the best net return per acre comes from a *good quality* tobacco crop, followed by *high yielding* groundnuts, and maize, followed by low quality tobacco, with low yielding groundnuts and maize at the bottom of the list. Tobacco, however, requires much labour and equipment in the way of barns, sticks, baskets, etc., and groundnuts require much labour, so that the best returns per man day come from maize, followed by *good quality* tobacco, followed by groundnuts sold unshelled, followed by groundnuts sold shelled, followed by poor quality tobacco.

When the time comes that overheads can and must be allocated and the cost of ox labour apportioned, the necessity for producing high quality tobacco and good yields of groundnuts will become greater. Maize will remain the easiest and most profitable crop to grow in terms of cash plus leisure, so long as there is an internal or external market that will take maize off the farm at one penny per lb. and the prices of groundnuts and tobacco remain much as they are. It is also unlikely, unless the prices for tobacco and groundnuts increase considerably, that it will ever pay the farmer of fertile plateau soils to specialize in alternative cash crops to the exclusion of his subsistence requirement of maize.

Unit Farm—Makanga

The tenant, with his family of wife and child, has completed one year's successful farming with two acres of sugar cane and a rotation of arable crops (Annual Report II, 1959/60).

Supervision was close during the early part of the year but less as the season progressed. Records were kept of all man days worked to the nearest half day on any crop or operation. Direct contact between the European staff and the tenant were avoided as much as possible and advice and direction was carried out through the Senior Agricultural Instructor on the staff.

The entire project has been financially independent and the normal records demanded of any business have been kept. A water rate of £3 per acre has been charged plus 10 per cent. of capital invested as an annual rent. The revenue per acre to any organization running the Marsh project would amount to £5-11s-0d per acre.

TABLE I
Trading Account
31st October, 1961

<i>Purchases and Expenses</i>				<i>Sales and Receipts</i>			
	£	s	d		£	s	d
Rent and Water Tariff ..	24	4	0				
Seed: ..	£	s	d	Crops: ..	£	s	d
Ex. Station ..	4	11	7	Legumes ..	6	18	0
Ex. U.G. ..	4	15	1	Cotton ..	10	19	2
			9 6 8	Sugar ..	82	8	0
				Onions ..	104	16	10
Wages				Drawings (food)	21	2	8
Self ..	£64	10	0				
Hired: ..	7	6	0				
			71 16 0	Valuations:			
				Closing ..	25	10	9
Tractor ..			11 0 0	Opening ..	23	8	10
Sundries ..			0 10 0				2 1 11
			116 16 8				
Profit ..			111 9 11				
			£228 6 7				£228 6 7

The trading account shown in Table I indicates the degree of success of the year's operations. The high sales of onions should be treated with reserve as the market is limited and prices would be much lower if bigger supplies were available. The sales of legumes and cotton were low as yields reflected the general standard of husbandry. Sugar is reasonable at an average yield of 42.5 tons of cane/acre but this should improve in the light of future agronomic findings on the station.

Costings of all crops were kept and are too extensive for publication here but the following are of interest.

TABLE II

<i>Crop</i>	<i>Profit/acre</i>			<i>Man day worked</i>		<i>Profit/Man day</i>		
	£	s	d					
Beans ..	1	1	6	42	..	0s-6d		
Sugar ..	173	0	6	152	..	2s-1½d		
Onions ..	175	5	0	133	..	26s-4d		
Maize ..	0	9	6	75	..	0s-1½d		
Groundnuts ..	4	10	6*	112	..	0s-9½d		
Cotton ..	2	2	7	151	..	0s-3½d		

(* This shows a loss).

In arriving at the profit/acre the family's labour has been charged at 1s-10d per day (skilled labour). It will be seen that all crops with the exception of groundnuts have been more remunerative than the minimum daily wage of 1s-8d per day.

Table III shows the amount of food drawn from stock during the year. It is indicated that one acre, double cropped should suffice to supply his needs.

TABLE III
Recorded Food Consumption

<i>Crop</i>					<i>Acreage required</i>
Maize	..	1,966 lb.	..	..	1
Legumes	..	513 lb.	..	..	$\frac{1}{2}$
* Vegetables	..	105 lb.	..	..	$\frac{1}{4}$

= 2 acres (1 acre double
cropped)

The family worked an average of 245 days each during the year, which could be improved.

Excluding onions, cane has been his most successful crop. This is encouraging as the Marsh Scheme will almost certainly be based upon sugar production. The cut cane output per day was very low at 0.58 tons but can be improved by adopting a more realistic harvesting system. In a large scale enterprise cutting would almost certainly be on a community basis and an output of 2-4 tons/man day would have to be achieved.

CHEMICAL WEED CONTROL TRIAL, CHITEDZE

This was a randomized block experiment with five treatments and seven replications, three of which followed tobacco, two sweet potatoes and two Rhodes grass ley. The object of the trial was to find out how best to use 2-4D to control annual weeds which consisted mainly of the Monocots, *Eleusine indica*, *Chloris virgata*, *Setaria palidifusca*, *Chloris gayana* and *Rhyncheletrum repens*, and the Dicots, *Fernonia cinerea* and *V. poskeana*, *Leonotis* sp., *Trichodesma zeylanicum*, *Ageratum conyzoides* and *Bidens* sp. with some *Solanum panduriforme*, *Nicandra physaloides*, *Amaranthus graecizans* and *Euphorbia heterophylla*. Of these only the *Euphorbia* appeared to be resistant to 2-4D at 2 lb. per acre a.i. in whatever way the latter was applied. Monocot seeds were prevented from germinating, but the spray had little effect on seedlings over 1 inch high. Most Dicots were killed as seedlings. Treatments and yields are given below.

TABLE I

Effect of 2-4D on weed control in maize

Variety: Mthenga

Yields: lb./acre grain

Treatment	Yield	Plants/ acre	Barren plants	lb./ cob	Eye scores of weeds ex 70	
					6/1/61	13/6/61
(1) Not weeded at all ..	3,175	12,320	1,470	.444	54	61
(2) "Clean" weeded (6/12, 9/1, 9/2)	4,890	12,200	140	.615	32	23
(3) 2 lb. 2-4D pre-emergence (25/11) only—no hand weeding ..	4,400	12,010	810	.596	25	43
(4) Hand weeded (6/12 and 9/1), then sprayed with 2 lb. 2-4D (12/1)	5,240	12,490	170	.646	28	18
(5) 2 lb. 2-4D pre-emergence (25/11) followed by hand weeding (9/1)	4,910	12,720	880	.630	23	37
Mean Yield/acre ..	4,520	L.S.D. 5% ..	775	Coef. Varn. ..	15.5%	

Pre-emergence spray only gave good early control of weeds and yields not much lower than the clean weeded control. It left a very weedy stubble however. This can be largely overcome by a good banking treatment in January. This combination (treatment 5) is probably the best to adopt. Alternatively excellent yields and weed control can be obtained by giving one or if necessary two early hand or mechanical weedings and spraying the *clean* maize crop immediately after. The effectiveness of this treatment depends largely on how well the early hoeing is done, and it must not be left for more than a month after the maize has germinated. The cost of this spray is approximately 20s per acre for the spray, and a Dorman tractor sprayer with a 40-gallon tank and a 12-ft. spray boom should cover about two acres per hour.

2. CHEMICAL WEED CONTROL, CHITEDZE

Four replications of five treatments to compare no weeding and hand weeding with various methods of using a spray of 1 lb./acre a.i. of 2-4D, were laid down at Chitedze on groundnuts following maize and Rhodes grass. It had been observed in previous years that heavier concentrations of 2-4D caused considerable damage to the groundnuts. It was evident this year that 1 lb./acre 2-4D was not sufficient to give a really efficient pre-emergence kill of weeds.

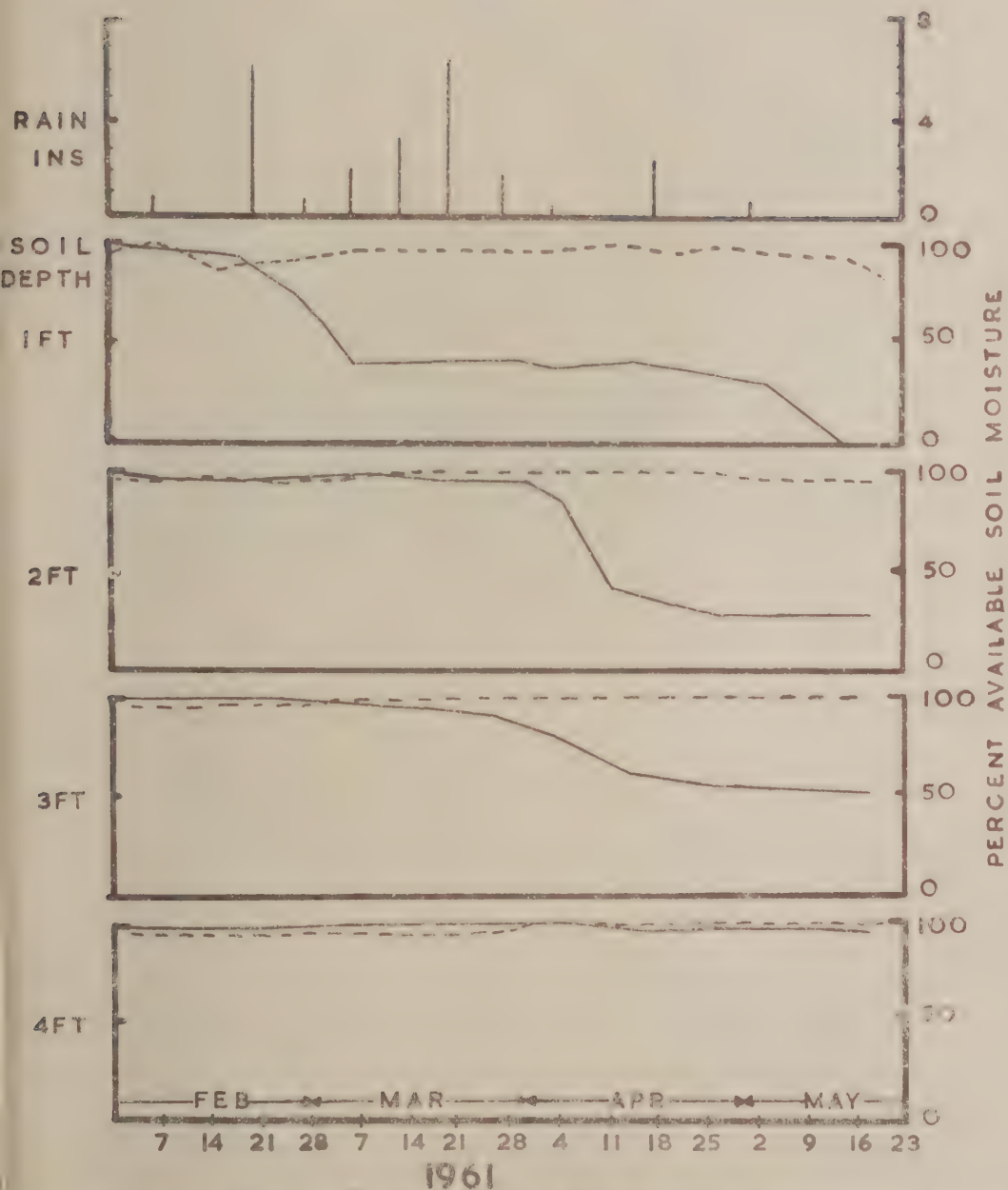


FIG.1 Soil moisture use under tobacco, Chitedze
 Covered plots ——— Uncovered plots - - - -

TABLE II
Effect of 2-4D and weed growth on groundnuts
Variety: Mwitunde *Yields: lb./acre shelled nuts*

<i>Treatment</i>	<i>Yield/ acre</i>	<i>Hills/ acre</i>	<i>Score for weediness 6/1/61 Max 40 (no weeding done)</i>
1. No weeding	480	26,560	19
2. Hand weeded 9/1 and 9/2/61	1,170	27,590	25
3. 1 lb./acre 2-4D pre-emergence 25/11/61—no further weeding	680	27,040	8
4. Hand weeded 9/1 then sprayed 1 lb./acre 2-4D 12/1/61	940	27,710	28
5. 1 lb./acre 2-4D on 25/11 plus one hand weeding 9/1/61	1,060	27,770	19
L.S.D. 5 per cent.	275	Coef. Varn	20.8%

Observations on the residual effects of 2-4D on various legumes, reported in the next section, indicate that groundnuts may be planted safely two weeks after a pre-emergence spray of 2 lb./acre 2-4D, which is an effective weed control measure. This will still allow the groundnuts to be planted by mid December. As it appears to be important to keep the groundnut crop clean right through to harvest, 2-4D has only a limited use with groundnuts and hand weeding in the later stages of growth will almost certainly be necessary.

SOIL PHYSICS AND IRRIGATION

Soil Physics

Evaporation and Transpiration Water Losses in Tobacco at Chitedze

Preliminary observations were undertaken in the 1959/60 season on a study of relative water losses due to evaporation and transpiration of maize and tobacco. As a result of these it was decided to carry out a more detailed experiment during the 1960/61 season using Burley tobacco as the test crop.

Six plots 24×24 feet were planted to tobacco at three by two feet spacing at the end of December, 1960, and duplicate sets of gypsum blocks were installed at foot intervals to a depth of four feet under each plot this covering the approximate rooting depth. When the tobacco was established and the soil profile was at field capacity, the soil surface on three of the plots was covered by black plastic material, impermeable to water, in order to eliminate water loss from these plots by evaporation, and to prevent further rainfall from entering the soil. Throughout the season gravimetric soil moisture determinations were made under the covered and uncovered plots to check available moisture use.

Fig. 1 shows graphically the seasonal loss of available moisture due to transpiration only (between one atmosphere and wilting point) under the covered plots which received no rainfall, compared with the uncovered plots where, despite considerable loss due to evapotranspiration, runoff and drainage, the profile was kept replenished by rain throughout.

The seasonal water loss from the two treatments is summarized in Table I. Although soil moisture samples were taken periodically these were not sufficiently frequent to justify accurate tabulation of the rate of moisture removal.

The figures for total water loss from the uncovered treatment represents use by the plant as transpiration, and losses due to evaporation, runoff and drainage. The estimated loss due to runoff and drainage is therefore 10.81 inches or approximately 42 per cent. The data shows that transpiration has only accounted for about 23 per cent. of the loss due to evapotranspiration, the remainder being due to evaporation from the soil surface. It is to be expected that the value for transpiration as determined on the covered plots may somewhat underestimate that occurring under natural field conditions as it was not possible to measure crop catchment of incident rain and also a certain amount of catchment occurred on the plastic covers, though this was relatively small.

Despite this it is obvious that a very high water use efficiency has been obtained under the covered treatment, an inch of water producing approximately 380 lb. of cured leaf, compared with 90 lb. on the uncovered plots.

A study of nitrate concentration under the two treatments shortly after harvest revealed a marked but not altogether unexpected difference between them. The figures obtained are presented in Table II.

The accumulation of nitrate in the surface soil of the covered plots shows that leaching had effectively been prevented under this treatment, while the uncovered plots showed marked leaching. The higher concentration between three and four feet under both treatments also indicates the approximate extent of the tobacco root system. This was confirmed by subsequent root washing studies which showed that there were virtually no roots below a depth of three feet in either treatment.

TABLE I

Summary of Total Water Use and Yields from Tobacco with and without Plastic Covers to a depth of Four Feet

Treatment	Profile Water Storage (in.)		Profile Water depletion (in.)	Rainfall received (in.)	Total water loss (in.)	Mean Yield cured leaf (lb./acre)
	19/1/61	25/4/61				
Covered	11.99	8.81	3.17	Nil	3.17	1.230
Uncovered	11.98	11.29	0.69	24.16	24.85	1.264

Estimated evapotranspiration (Penman) between 19/1/61 - 25/4/61 = 14.04 inches.

A further point of interest revealed by these studies was the much greater development of fine roots in the surface foot under the covers showing that maximum utilization of the available moisture had been made by the system.

Other Stations

Details of Soil Physics work in progress at other stations (Bvumbwe, Makanga, Mimosa and Swazi) have been included with the crops on which the work has been carried out, and reference should therefore be made to the appropriate sections of this report.

TABLE II

Nitrate Concentration under Covered and Uncovered Tobacco after Harvest (1961)

Depth (in.)				Nitrate p.p.m.	
				Covered	Uncovered
0-3	..	..	..	24	9
3-6	..	..	..	6	7
6-12	..	..	..	7	1
12-24	..	..	..	4	2
24-36	..	..	..	6	1
36-48	..	..	..	15	18

Figures are means of six profiles.

Irrigation Studies, Makanga

1. INTRODUCTION

The object of the irrigation studies at Makanga is to build up a body of knowledge on irrigation farming against the day when an extensive irrigation project is started. This is being pursued in three stages by:

- (i) growing as wide a range of crops as possible to assess their potential;
- (ii) making more detailed studies of the more promising crops especially with regard to their water use and cultural requirements. This has led into evaporation studies and soil moisture investigations in association with the Water Development Department and the Agricultural Chemist, Chitedze;
- (iii) economic studies. All operations on irrigated crops are costed. A unit holding has been started on 4 acres, half under sugar cane, run by a tenant. This is reported elsewhere.

All work described has been carried out at Makanga Experiment Station in the hot dry Lower Shire Valley during 1960 dry season and 1960/61 wet season. The soil is a deep grey-brown calcareous alluvium of recent origin, satisfactory in nutrient status and texturally variable but with clay loam predominant.

2. CROPS AND YIELDS

In pursuing the first object of the irrigation studies many crops have been examined to assess their potential for a commercial irrigation project. After four years, possibilities of extending the range are limited. Two new crops were tried: castor in the dry season was promising with a yield of the order of 1,500 lb./acre but was the usual failure when planted in the rains; Guar, the cluster bean (*Cyamopsis psoraloides*), gave a reasonable yield but its value is unknown.

The results of this phase of the work are brought up to date in table III. Crops on which no new information is available have been excluded and reference must be made to last year's report. "Best Yields" are given for any crops where an improvement has been obtained from some cultural practice detailed later in the report. Presenting the value of the crop is difficult. The prices given are those which it is certain could currently be obtained by a farmer in the area: large scale production might flood the market and bring prices down.

The general level of yields in cotton, maize, beans, groundnuts and onions has risen through improvements in technique and the potential returns are greater than that calculated from average yields over the past four years. Yields of wheat have been so consistently low that it can be excluded from future work. A new variety of rice, Blue Bonnet, especially suited for irrigation as opposed to swamp conditions, was grown in the wet and dry season: it failed in the dry and yielded only 170 lb./acre in the wet season. Sesame failed under irrigation in the wet season.

Mention must be made of the tree crops. Cocoa is reported elsewhere. Citrus is not yet bearing and shows some peculiarities. Cashew, avocado, robusta coffee, oil palms, pineapples and a number of timber trees have been established.

3. CROP WATER RELATIONS

(a) General Note

One of the most important aspects of the detailed work in the second phase of the irrigation studies is the determination of crop water requirements. This leads into the field of agricultural physics in which investigations have been made in conjunction with the Soil Physics section of the Agricultural Research Station, Chitedze, in collaboration with whom this part of the report has been written.

(b) Irrigation Control

The major use of water by crops is in evapotranspiration which is related to the evaporation loss from an open water surface. Crop losses are estimated by multiplying the evaporation pan loss by an appropriate irrigation factor. A water balance sheet is maintained half weekly by entering these losses, and also gains by precipitation and irrigation. When the deficit reaches a predetermined level (usually two inches) this quantity of water is applied. If the water gain exceeds the deficit at any time, the surplus is written off as loss by deep percolation.

Beginning in November, 1960, the pan used in irrigation control was changed from that at the "old" meteorological site to one with better exposure at the "new" site adjacent to the irrigated area. Both are Kenya M.O.W. type pans, screened, raised, painted black inside, with a 14 inch depth of water.

TABLE III
Yields and Value of Irrigated Annual Crops at Makanga

Crop		1960 Dry Season				To Date Since 1956 (5 years)			
		Date planted	Best yield	Weighted mean yield per acre	Acreage	Weighted mean yield per acre	Total acreage	Price to farmer	Gross return per acre to farmer
Maize	..	9/ 5/60	4,390 lb.	4,070 lb.	0.84	3,828 lb.	3.20	1½d/lb.	£20
Beans (Kidney)	..	6/ 8/60	1,615 lb.	1,322 lb.	0.87	1,021 lb.	2.25	4d/lb.	£17
Black Gram	..	11/ 8/60	—	567 lb.	0.93	567 lb.	0.93	5d/lb.	£11
Wheat	..	20/ 5/60	782 lb.	563 lb.	0.87	637 lb.	6.04	2d/lb.	£ 5
Onions	..	21/ 5/60	—	11.0 tons	0.47	8.0 tons	2.67	3d/lb.	£200
		(transplanted)							
Potatoes	..	31/ 5/60	—	6.8 tons	0.47	7.3 tons	1.34	1d/lb.	£62
Sesame	..	3/ 5/60	—	207 lb.	0.84	331 lb.	1.02	5d/lb.	£ 7
Castor	..	9/ 7/60	1,532 lb.	1,370 lb.	0.06	1,370 lb.	0.06	3d/lb.	£18
1960/61 wet season									
Cotton	..	Late Nov.	2,880 lb.	2,175 lb.	2.70	1,730 lb.	12.27	6d/lb.	£44
Maize	..	24/11/60	—	4,311 lb.	.84	2,922 lb.	6.94	1½d/lb.	£15
Groundnuts	..	6/12/60	1,298 lb.	1,090 lb.	.50	922 lb.	3.92	5d/lb.	£19
Soya	..	27/ 1/61	—	1,205 lb.	.84	1,665 lb.	4.00	3d/lb.	£21
Guar	..	8/12/60	—	697 lb.	.03	697 lb.	.03	—	—

(c) *Evaporation Studies*

As accuracy in estimating the evaporation from an open water surface is essential for the success of irrigation control a study was made of various estimates. The indirect method of solving Penman's equation with the aid of McCulloch's tables has been taken as the basic standard against which direct estimates with the pan described, piche evaporimeters, and the Gunn-Bellani radiation integrator, have been compared by correlation. The coefficients of determination ("r²" values as percentages) obtained are presented in Table IV.

TABLE IV

Coefficients of Determination for correlation of Penman with Pan, Piche and Radiation Integrator. 10 day means

10 day means				Dry Season May–November n=19	Wet Season December–April n=18
Pan (in.)	..	..	..	99.0	67.1
Piche (ml.)	..	..	..	98.8	33.6
Integrator (ml.)	..	..	..	91.6	49.4
Y=evaporation by Penman's equation 10 day means (in.)					

It can be seen that the best direct estimate of Penman can be obtained from the regression equation for Penman/Pan. These equations are:

$$\text{Dry season.} \quad Y=0.046+0.6012 \times$$

$$\text{Wet season.} \quad Y=0.094+0.6006 \times$$

The seasonal change in the relationship between Penman and pan is shown in Fig. 1. This shows that from June to November pan evaporation increasingly exceeds the Penman estimate so that the Penman/Pan ratio changes systematically from 0.95 to 0.65. This change in ratio can be correlated with many factors including wind, radiation, and advance of the season but none sufficiently closely to justify a conclusion on the cause. It appears that the Penman equation increasingly underestimates the energy available for evaporation. Consideration of the conditions at Makanga suggest that there are advected energy supplies available to the Pan of which Penman takes no account.

With the onset of the rains the position is reversed: the Penman/Pan ratio exceeds unity approaching 1.3 at times. At this time Penman apparently overestimates the available energy suggesting that net energy cannot satisfactorily be derived from Solar radiation from the Smithsonian tables and hours of sunshine, but needs to be measured direct.

(d) *Soil Moisture*

In considering the water used by a crop in a given period any changes in the moisture content of the soil must be taken into account. To do this, use has been made of direct oven drying determinations and gypsum electrical resistance blocks; as previously reported textural differences have hampered this work.

The results of a study of the relationship of electrical resistance and moisture content of the top soil *in situ* is given in Fig. 2. A value is also obtained of the available moisture holding capacity of the top soil: 2.51 inches per foot compared with direct determinations of 2.75 inches per foot. The use of blocks can indicate that when the resistance becomes greater than 3 logohms drying out of the profile is

certainly occurring and nearly half the available moisture has been depleted: changes in resistance at less than 3 logohms are not open to accurate interpretation due to the insensitivity at low moisture tensions.

(e) *Development Studies*

Determinations of leaf area have been resumed using the method previously described (ref. A.R.II 57, 58, p. 129). Although they do not permit direct determinations of the crop water requirements, a valuable measure of the development of the crop is obtained for comparison with its water use. In addition the flowering and fruiting of a number of crops has been studied.

(f) *Water Use Pattern of Crops*

A number of crops have been irrigated at a range of irrigation factors, and the soil moisture changes determined. It has been possible to observe how successful a factor is in meeting the water demand of a crop. From this the water use can be deduced. In this context the water use of a crop is considered to be the losses from the soil/plant/air system when the soil is not above "field capacity". It therefore consists largely of evapotranspiration losses but may include deep percolation occurring at the higher tensions i.e. less than $\frac{1}{3}$ atmosphere or "field capacity." The results for crops studied to date are given in Fig. 3.

Considering the crude methods used and empirical nature of the quantity measured, the results are relatively consistent. The water use rises with increasing leaf area from less than 0.5 to approximately 1.5 times the Penman estimate of evaporation. At this point leaf area increases at a reduced rate and water use remains constant during a period of maximum reproductive activity, falling subsequently as the crop matures. The high factors reached in water use cannot be wholly accounted for by deep drainage and suggest that the pan and Penman underestimate the energy available to the plant for evaporation: this is likely with small irrigated plots set in semi-arid country from which hot dry winds can blow through the growing crops bringing advected energy.

Sugar cane also gives a value approaching 1.4. Using the pattern obtained with maize, theoretical water balance sheets were constructed for 20 rain fed maize crops over the last 7 years. The mean soil moisture balances during tasselling, 8 to 12 weeks, were compared by correlation with the yields which ranged from 430 to 3,834 pounds of grain per acre. A coefficient of determination of 62 per cent. was obtained which was higher than that obtained with any other factor including temperature and rain. In this context it lends support to the validity of the findings on water use.

(g) *Efficiency of Irrigation*

Irrigation water is measured onto plots through a standard rectangular orifice. To check the accuracy of the applications a series of soil samplings was conducted before and after irrigation and the quantity actually applied determined by the difference in the soil moisture found gravimetrically by oven drying. 150 samples were taken from 15 plots and the mean depth of water actually applied was 100.96 per cc. t. of that measured onto the plots. The coefficient of variation between plots was 51 per cent. and within plots was 33 per cent.: this wide variation may partly be due to variations in the bulk density, for which a mean value was used, rather than the quantity of water applied.

4. AGRONOMY OF IRRIGATED CROPS

(a) *Water Rates—Winter Crops*

A number of simple experiments were conducted in which a range of irrigation factors was applied to several crops. The yield data are given in Table V.

(i) *Wheat*. With wheat (Rhodesia No. 2) previous findings were repeated: the crop does best when permitted to draw deeply on soil moisture reserves. Rust, weed competition and bird damage were again extensive resulting in low yields. The use of gypsum resistance blocks enabled some deductions to be made on the water use of the crop and these have been given in Fig. 3.

(ii) *Vegetables*. Yields of potatoes were reduced compared with last year. This was the result of poor seed and an attack of blight which was severest on the higher water rates. Onions (Cape Flat) gave the best yields to date. There was no response to different water rates. An observation was made on the keeping qualities of both these crops: in the case of onions the proportion of sound bulbs after 4 months was 50 per cent., and after 7 months 26 per cent., while for potatoes after 4 months only 12 per cent. remained whole. No differences were detected between water rates.

(iii) *Beans*. The experiment with beans (Canadian Wonder ex Kirchhoffs) was laid down over gypsum resistance blocks. Their readings enabled a water use pattern to be postulated and this has been presented in Fig. 3. Water rates less than the water use resulted in a reduction in yield: being quick growing and shallow rooted the crop was unable to compensate for low water rates by drawing on soil moisture reserves.

(iv) *Lucerne*. Yield differences between water rates in the Lucerne crop, though statistically significant, defy interpretation. The yields are from 9 cuts in 15 months.

TABLE V
Yields of Various Crops at Different Water Rates

<i>Irrigation factor</i>	<i>Wheat lb./acre</i>	<i>Potatoes tons/acre</i>	<i>Onions tons/acre</i>	<i>Beans lb./acre</i>	<i>Lucerne tons/acre hay</i>
.4	782 (2)	—	—	—	—
.6	545 (6)	7.65 (6)	10.8 (4)	979 (16)	—
.8	421 (6)	—	—	1,348 (18)	10.42 (48)
1.0	505 (10)	6.72 (10)	11.1 (6)	1,346 (20)	9.74 (69)
1.2	—	—	—	—	8.84 (87)
1.4	—	5.93 (16)	11.1 (10)	—	10.60 (98)
1.5	—	—	—	1,615 (26)	—
1.6	—	—	—	—	9.22 (126)
L.S.D. 5%	122	1.7	1.7	188	1.17
C. of V.	38.7%	17.1%	15.4%	13.2%	17.9%

NOTE: Figures in brackets after yields are the total amounts of irrigation water applied in inches to the growing crop.

(b) *Water Rates—Supplementary Irrigated Summer Crops*

(i) *Groundnuts*. A study of the results of the previous season's work on this crop suggested that the water use pattern could take one of two forms: either the crop consumes water at 0.5×open pan for 8 weeks followed by a sharp rise to 1.3×open pan or the use rises proportionally with leaf area from 0.3 to 1.5×open pan. These patterns were tested in an experiment together with a control treatment, no irrigation,

and a low rate, $0.6 \times$ open pan. Three varieties with different maturation periods were introduced so that if water use were related to development and the physiology of flowering and fruiting it would be shown by a comparison of the varieties. A secondary consideration was to see if long term and potentially higher yielding varieties would be more profitable if the growing season was lengthened by irrigation. These treatments were arranged in a split plot design with varieties allocated to sub-plots. The yield data is presented in Table VI. Early Runner and Gambia both yielded reasonably: Mwitunde is not worth considering. Gambia appears more sensitive to water stress and Early Runner more sensitive to over watering.

The results of moisture and development studies are given in Fig. 4. It was impossible to distinguish between the two higher water regimes in terms of soil moisture. Provisional water use pattern is found in Fig. 3. The flowering curves explain the failure of Mwitunde in this area. It is not length of season but failure to flower properly at high temperatures.

(ii) *Maize*. Previous reports describe the findings on water requirements of maize in the dry season, and the response to nitrogen in the absence of water stress. An experiment was laid down this year to see if the dry season requirement held true in the rains and whether a response could be obtained from nitrogen: rain fed crops do not respond to nitrogen.

There were no significant responses but the yield was exceptionally high (see Table III). Heavy rain at tasselling obliterated any treatment effects on soil moisture though water use was later $1.5 \times$ open pan.

TABLE VI
Effect of Irrigation Treatments on the Yield of three Groundnut varieties.
(Yield of nuts pounds per acre)

Irrigation treatments factors	Gambia	Early runner	Mwitunde
Rain fed control	944 (0)	1,202 (0)	492 (0)
$0.6 \times$ open pan	1,298 (2)	1,210 (2)	468 (2)
0.5 to 8 weeks followed by 1.3 ..	1,168 (6)	851 (10)	419 (10)
0.3 increasing with leaf area to 1.5.	1,073 (8)	823 (14)	347 (16)
L.S.D. 5%	—	169	—
C. of V.	—	8.9%	—

NOTE: The bracketed figures are the quantities of irrigation water applied in inches: within the same irrigation treatment larger amounts have been applied to later varieties as a result of longer maturation periods.

(c) *Irrigation of Cotton*

(i) *General*. In previous years it has been observed that cotton grown on land which has carried an irrigated crop in the preceding dry season yields in the order of 2,000 lb. of seed cotton per acre which is double that obtained from unirrigated land. Supplementary irrigation during the growing season has not led to further increases. There is a loss of crop by the shedding of buds and bolls preventing the full potential of the crop being realized. Shedding has been studied in previous seasons. In 1958-59 application of plant growth substances but not insecticides appeared to reduce shedding: in 1959-60 the reverse was observed though the year was a typical, with

high sunshine hours at the time of fruit set. Evidence of a correlation between high February rainfall and yield led to an experiment in which a boost of irrigation in February gave an insignificant increase in yield.

It is against this background that the cotton irrigation experiments of 1960-61 season were planned. Dr. Dale of Namulonge took over the plant growth substance approach. Locally planned work consisted of a Protection and Irrigation trial in which it was intended to see if insecticidal protection would enable cotton to obtain greater benefit from irrigation and vice versa, and an examination of two varieties.

(ii) *Irrigation and Protection Trial.* The treatments were as follows:

Factor P: Protection with 85 per cent. sprayable sevin powder at $\frac{1}{2}$ lb. a.i. per 10 gallons using a knapsack sprayer with tail boom.

Levels: P₀ No protection.

P₁ Partial protection according to Cotton Pest Research Team recommendations. 8 weekly spraying beginning on 27-1-61 starting at 23 gallons per acre rising to 33 gallons per acre.

P₂ Complete protection from establishment. 13 weekly sprayings beginning on 24-12-60 starting at 10 gallons per acre rising to 33 gallons per acre.

Factor I Irrigation.

Levels: I₀ None: Rainfall only.

I₁ Medium: 1.6×open pan when L.A.I. reached 1.6. Total water applied 14 inches.

I₂ High: 2.0×open pan when L.A.I. reached 2.0. Total water applied 18 inches.

I₃ Early Boost: 1.6×open pan for 4 weeks from 1st flower. Total water applied 4 inches.

I₄ Late Boost: 1.6×open pan for 4 weeks starting 3 weeks after I₃. Total water applied 6 inches.

The protection and irrigation treatments were combined factorially in a split plot design with protection treatments allocated to the main plots. In the text below treatment combinations will be referred to by a pair of numbers the first showing the level of P and the second the level of I.

The experiment was dry planted on 28th November but was supplied to the extent of over 50 per cent. following hail damage. A total 6 inches of water was used in establishing the crop. Spacing was 3 ft. × 2 ft. × 3 plants.; the variety was A637.

Establishment was not good. Growth was less rank than usual; comparison with similarly treated cotton in other fields suggested this was the effect of the preceding lucerne ley.

Detailed studies were made of growth, fruiting and shedding by fortnightly plant stripping of a 2 hill sample per plot and by daily white flower counts and weekly tagging and shed collection from a sample of 3 hills per plot. From these a general picture of the development of the crop has been built up.

The yield data is given in Table VII. The most interesting feature is the interaction of protection and irrigation. Neither protection alone (treatments 10, 20) nor irrigation alone (treatments 01, 02, 04) gave a significant increase over control (00) but when combined (11, 12, 14, 21, 22, and 24) a significant response is obtained raising yields to levels unprecedented for Makanga. (I₃) treatments are not considered as the water was applied too early).

TABLE VII
Protection and Irrigation of Cotton
(Yields of seed cotton in pounds per acre)

<i>Irrigation</i>			<i>Protection</i>			<i>Mean</i>
			<i>P₀</i>	<i>P₁</i>	<i>P₂</i>	
<i>I₀</i>	..	..	2,410	2,466	2,098	2,284
<i>I₁</i>	..	..	2,257	2,914	2,977	2,669
<i>I₂</i>	..	..	2,347	2,807	2,948	2,654
<i>I₃</i>	..	..	1,769	2,649	2,353	2,217
<i>I₄</i>	..	..	2,285	2,835	2,801	2,594
Mean	..	..	2,214	2,734	2,635	2,528
<i>L.S.D.</i>	<i>I Means</i>			<i>P means</i>		<i>Body of Table</i>
5%	160			317		296
.1%	316			2,325		560

C. of V. Error (a) 9.2% Error (b) 7.3%.
 Main plot gross 15 yds. × 50 yds. Subplot gross 10 yds. × 15 yds.
 Sub-plot net 4 yds. × 10.7 yds. (16 hills).
 2 replications.

The fruiting and shedding data were studied in an attempt to throw some light on the yield effects. Only in flower production were major differences detected which could be attributed to treatments. These are shown in Fig. 5. The tendency was for protection to affect the flowering curve as it was rising to a peak and irrigation as it was falling.

Protection saved young buds from insect attack just after they were exposed: this is apparent from the delay of 3 weeks in the response of the flowering curve to treatment *P₁*. This explains why little difference was observed in the numbers of bud sheds collected: the buds concerned were too small to collect (up to 11th February only 30 per cent. of sheds were received). Other work, by the C.P.R. team in a pupal garden, showed that 78 per cent. of the over-wintering pupae of the Red Boll worm emerged in January. Analysis of shed buds collected shows that initially fewer were damaged from protected treatments. This can be seen in Table VIII.

Irrigation increased flower production in two ways: by reducing bud sheds and increasing the number of fruiting points produced (non-irrigated plots stopped sympodial growth with water stress).

TABLE VIII
Analysis of Sheds. Percentage Damaged by Insects

<i>Date</i>			<i>Buds</i>			<i>Bolls</i>		
			<i>P₀</i>	<i>P₁</i>	<i>P₂</i>	<i>P₀</i>	<i>P₁</i>	<i>P₂</i>
19/1	..	..	81	61	43	—	—	—
26/1	..	..	87	78	69	—	—	—
2/2	..	..	86	75	50	100	100	100
9/2	..	..	84	45	47	38	50	18
16/2	..	..	47	46	52	48	11	27
23/2	..	..	54	32	52	33	28	27
28/2	..	..	35	31	44	28	22	28
9/3	..	..	—	—	—	16	15	10
16/3	..	..	—	—	—	16	22	20
21/3	..	..	—	—	—	5	5	5

The failure of protection or irrigation alone to increase yields was the result of the interaction between the flowering patterns they produced and the capacity of the plant to carry bolls. Only when applied together did they raise flower production sufficiently to exploit the carrying capacity of the plant to the extent of raising yields. No treatments appeared to affect the carrying capacity of the plant.

Deductions about the water use pattern of cotton were made from this experiment and have already been reported on (see Fig. 3).

(iii) *Varieties*. Last season a comparison of A637 and UPA suggested that variety was important in determining fruiting behaviour. These varieties were compared again this year as subplot treatments on the long term manurial trial in Field B. UPA was again slightly but insignificantly earlier: the difference in the final yields, which are given in Table IX, though significant, was small in view of the problem involved.

TABLE IX
Varieties under Irrigation
Yield of seed cotton in lb. acre

Variety		Yield
A637	.. ..	2,376
UPA	.. ..	2,196
L.S.D. %		
5	.. ..	117
1	.. ..	159
.1	.. ..	212
C. of V.		4.6%
Plot size gross 15 yds. x 5 yds.		
Nett 13.7 yds. x 3 yds.		

(iv) *Plant Growth Substances*. Detailed reporting and conclusions on the experiment will be left to Dr. Dale but the extract from the results in Table X is of interest. Insecticidal protection was again involved in an interaction: it did not increase yields unless certain growth substances were applied.

TABLE X
Effect of Spraying Plant Growth Substances on Castor in presence and absence of
insecticidal protection
(Yields in lb. of Seed Cotton per acre)

Plant growth substance at 50 p.p.m. sprayed twice					Unprotected by sevin	Protected by sevin
Naphthalene acetic acid					2,341	2,903
Duraset					2,194	3,231
4-Chloropheroxyacetic acid					2,212	3,283
2, 4, 5-trichlorophenoxypropionic acid					2,082	2,376
Control					2,722	2,471
L.S.D. 5%					579	—
1%					769	—
.1%					994	—
Coef. of Varn.					15.0%	—
Variety					A637	—

FIGURE EVAPORATION:

Penman Estimate and Pan loss, 10 day means, Penman ratio; Solar radiation at upper limit of atmosphere; Incoming radiation measured by Gunn-Bellani integrator.

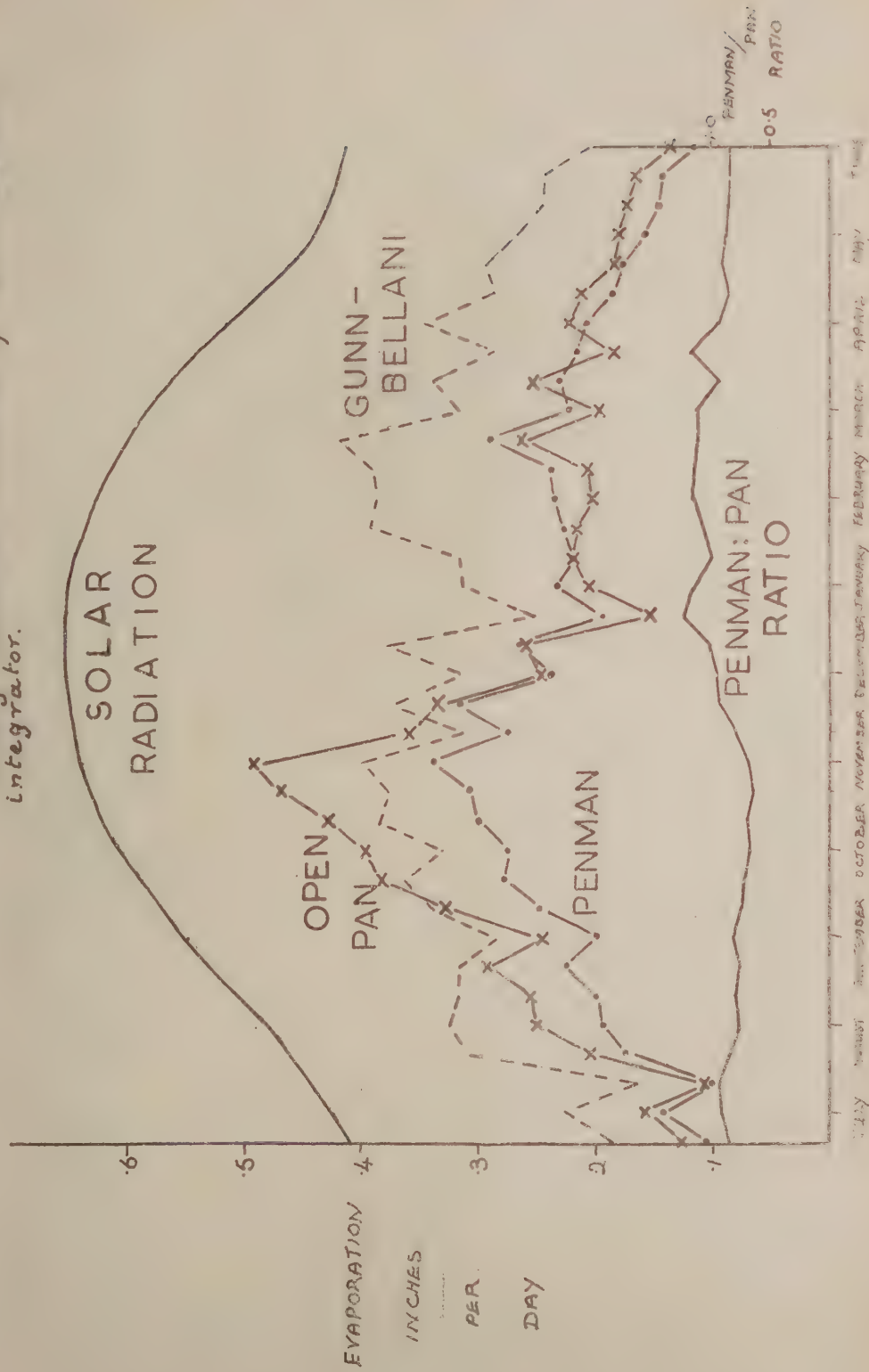


FIGURE SOIL MOISTURE: The relationship between resistance of gypsum blocks and moisture content of soil in clay loam 0-24 in.

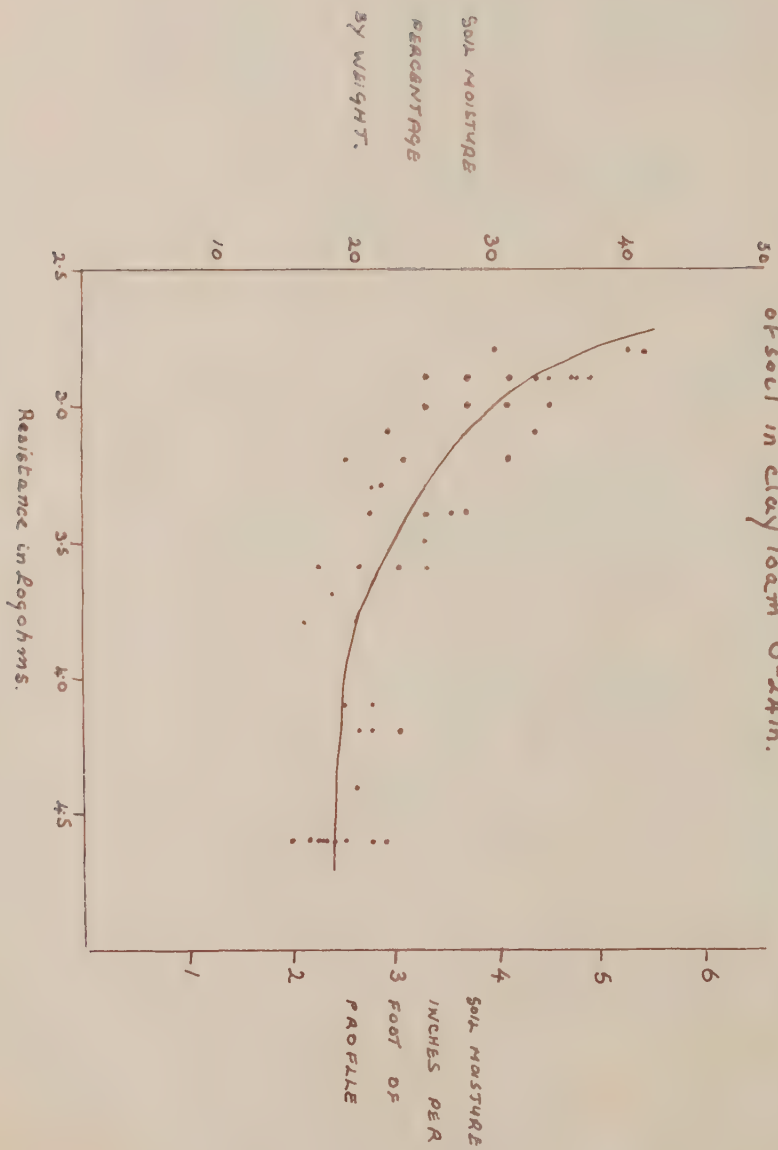
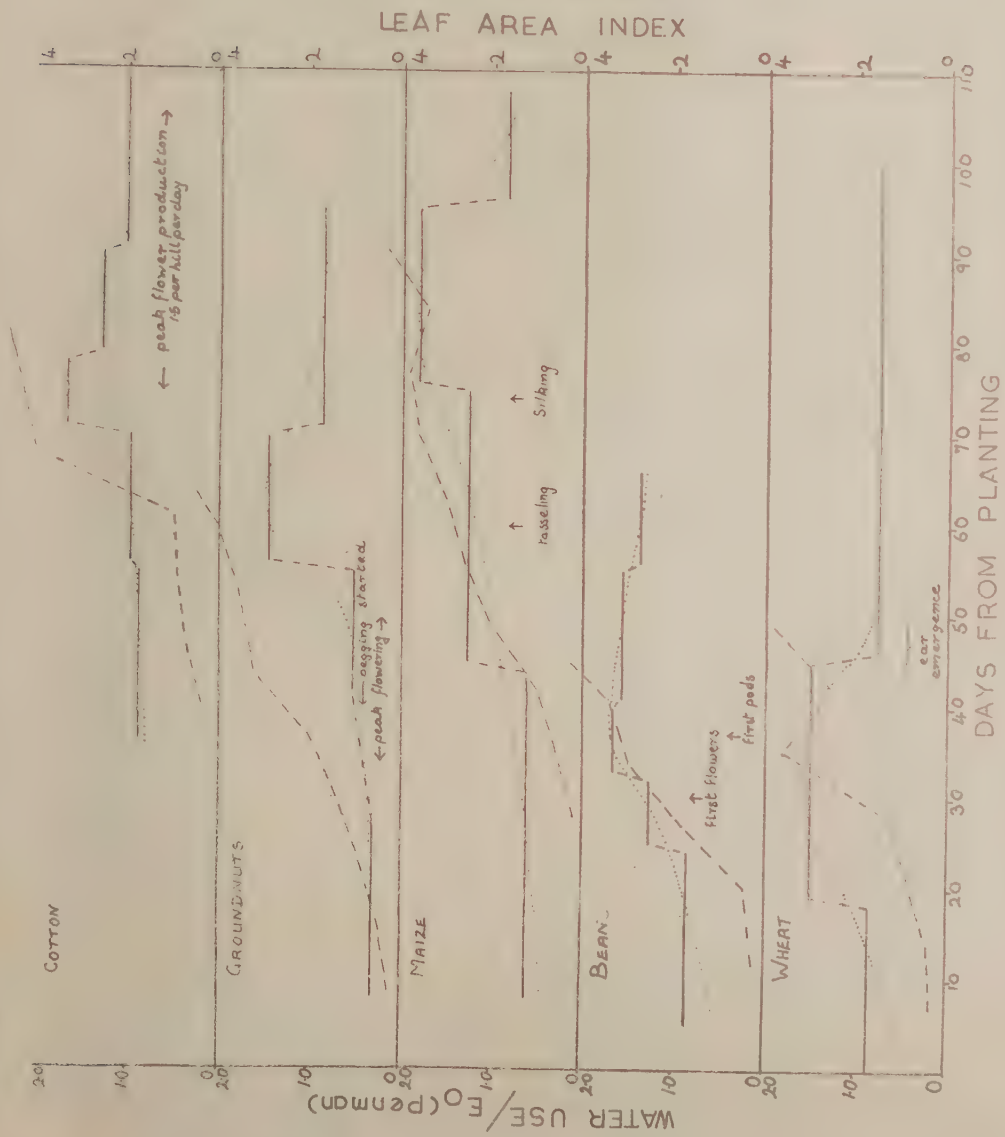


FIGURE PROVISIONAL WATER USE PATTERNS



Solid horizontal lines show for the period covered the ratio of the minimum quantity of water observed to prevent soil moisture tension rising above the level shown by a gypsum block resistance of 30 logarithms to the open water surface evaporation estimated by solving Penman's equation.

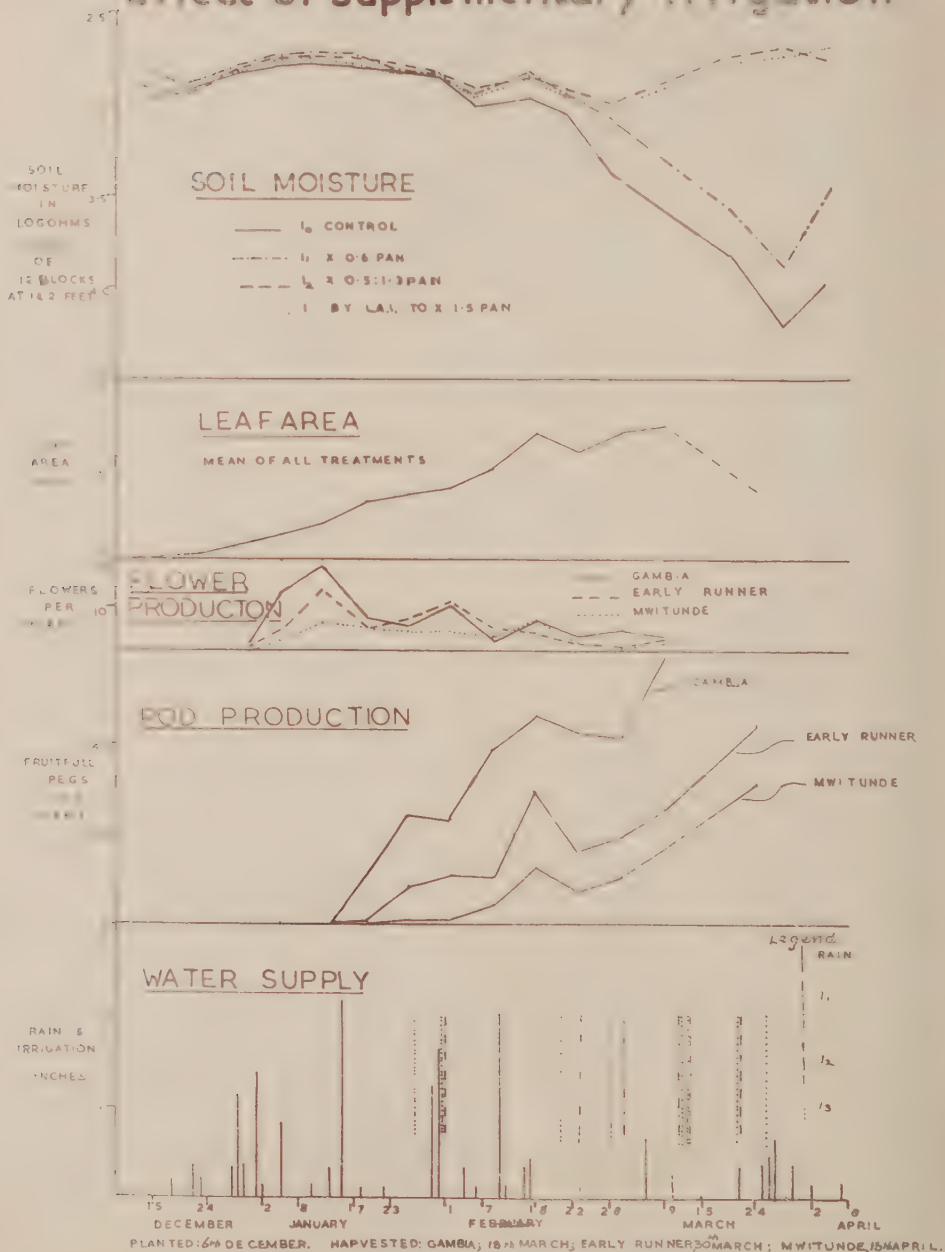
Dotted curves give the water use pattern considered to fit the observations best.

Broken lines show the measured leaf area and

FIGURE

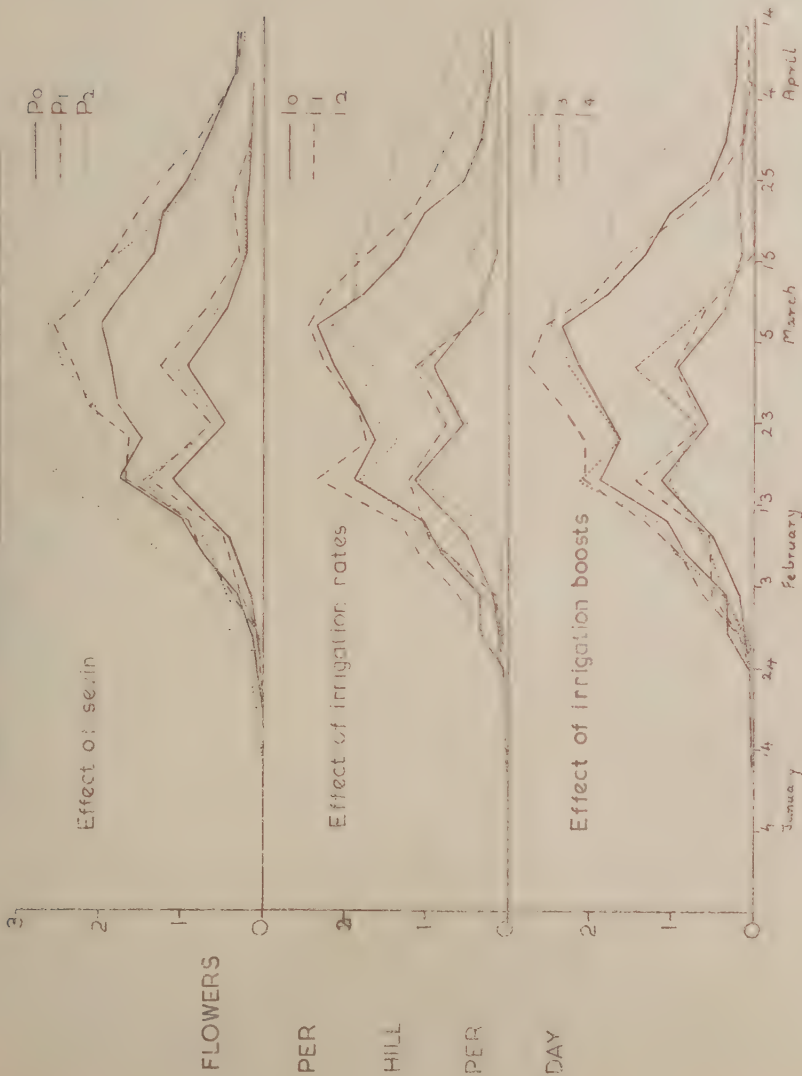
GROUNDNUTS

effect of supplementary irrigation



FIGURE

IRRIGATION AND PROTECTION FLOWER PRODUCTION TOTAL AND EFFECTIVE



The upper sets of lines show the total flower production derived from the mean white flower count for the previous four days. The lower sets indicate flowers given mature flowers at harvest. The difference between the upper and lower lines being the shedding occurring between flowering and harvest.

(d) Establishment of Irrigated Crops

No further work was done in this direction with dry season crops. An exploratory experiment was carried out on wet season maize, groundnuts and cotton. The problem is finding the correct irrigation technique at planting. Previous work with cotton suggested dry planting was best. Treatments are detailed in Table XI. With maize although there were no differences in germination, plant population was later significantly reduced on dry planted treatments as a result of subsequent over watering; a reduction in yield followed. The stand of groundnuts was improved by dry planting but this was not reflected in yields. With cotton dry planting gave the best germination but subsequent mortality was very high on all plots and yield data was not taken. The danger of over-watering at the beginning of the rains is emphasized.

(e) Fertility Studies

The long term irrigated fertility experiments were cropped as follows:

				1960			1960
<i>Experiment</i>				(4th dry season)			(5th wet season)
A3, NPK	..	..	..	maize	..	..	soya
B3, NPK	..	..	..	sesame	..	..	cotton
C3 levels F.Y.M.	..	..	..	grams	..	..	maize

In experiment A in the dry season 500 lb. of sulphate of ammonia per acre raised maize yields significantly from 18 to 22 bags per acre, while in experiment C the yield of wet season maize was significantly depressed by 10 tons per acre of F.Y.M. from 9 bags to 7 bags per acre. Among the remaining crops no suggestion of a response was observed to any of the fertilizers applied.

TABLE XI
Effects of Irrigation Treatments at Planting on establishment and yield of Maize, Groundnuts and Cotton

				<i>Maize</i>		<i>Groundnuts</i>		<i>Cotton</i>	
				<i>Yield lb./acre</i>	<i>Plant harvested</i>	<i>Yield lb./acre</i>	<i>Stand %</i>	<i>Hills per acre @ 8/12</i>	<i>Hills per acre @ 19/12</i>
Dry plant followed by 2 in. twice weekly to 12 in.				4,071	10,677	784	87.4	6,532	4,704
Dry plant followed by 4 in. twice weekly to 12 in.				4,068	11,505	742	88.0	6,612	5,752
Preirrigate 12 in. plant day after last irrigation				4,612	12,096	739	75.1	5,914	4,247
Preirrigate 12 in. plant 3 days after last irrigation				4,631	12,768	813	76.2	6,156	4,623
Preirrigate 12 in. plant 5 days after last irrigation				4,500	12,365	704	74.5	6,236	3,414
L.S.D. 5%				662	—	174	4.6	—	—
No irrigation at emergence				4,471	12,094	774	79.4	6,289	4,386
2 in. at emergence				4,281	11,664	746	81.3	6,289	4,709
L.S.D. 5%				419	—	109	2.9	—	—
Flat				4,445	12,051	815	81.1	6,321	4,891
Ridged				4,306	11,707	699	79.4	6,257	4,203
L.S.D. 5%				248	—	55	1.6	—	—
C. of V. (a)				17.7%	—	26.7%	27.4%	—	—
(b)				10.9%	—	13.8%	16.2%	—	—

Extract from Report of the Senior Agricultural Chemist

FERTILITY MAINTENANCE UNDER IRRIGATION

In the section dealing with tea, investigations into soil nutrient changes under tea are described. Although this aspect is of particular importance for perennial crops, a similar problem for annual crops has arisen, with the introduction of irrigation in the Lower River area, and the corresponding continuous cropping throughout the year. These soils are so well supplied with nutrients that depletion would hardly be expected. Soils from two fields at Makanga were therefore examined after they had been under NPK experiments for three years. Average figures for nine plots are given in the following table; earlier data being quoted for comparison.

Field A

Fertilizer level					Content of each nutrient in soil, for each individual level of fertilizer application			
N	P ₂ O ₅	K ₂ O			N %	P. p.p.m.	K (m.g.c. per 100 gm.)	
<i>Field A</i>								
0	0	0	..	..	Range .145-.195	980-1,512	1.00-1.70	
					Av. .166	1,206	1.33	
21	19	60	..	..	Range .15-.18	980-1,785	1.30-1.75	
					Av. .166	1,342	1.59	
		Residues burnt	..	..	Range .14-.20	1,036-1,365	1.15-1.80	
42	38				Av. .166	1,188	1.51	
		Oct. '56	..	..	.172	1,130	2.3	
		May '57	..	..	.172	880	2.9	
<i>Field B</i>								
0	0	0	..	..	Range .15-.20	1,190-1,960	1.30-2.65	
					Av. .169	1,536	1.80	
21	19	60	..	..	Range .14-.19	1,260-1,890	1.30-1.90	
					Av. .174	1,583	1.62	
		Residues burnt			Range .105-.180	1,295-1,170	2.15-3.40	
					Av. .159	1,589	2.97	
		Oct. '56	..	..	.15	978	2.0	
		May '57	..	..	.17	—	—	
Adjoining non-irrigated Field (1960)					.24	1,008	1.70	

It is seen that no appreciable difference exists between plots under the respective treatments, and this is generally reflected in the absence of any yield responses, except an increase of one third in the yield of onions, under potash application. This potassium response may be related to the fact that the higher level of potassium application (produced by burning on one plot, the crop residues produced on three plots), does cause some increase in the potassium content of the soil. It is however difficult to see how at this high status of this nutrient in the soil, these smaller differences in nutrient level can be so important, particularly on Field A, where the onions were grown.

A reduction of cotton yield had been induced by farm /yard manure. The increase in available phosphate status on plot B particularly is most likely due to the build up of organic matter in the soil from crop residues. This is more marked in B than in A, apparently due to the different amounts of levelling, and hence removal of the initial top soil that was involved when laying out the area. Comparison with an adjoining non-irrigated field shows that the potash and phosphate levels are little different from those on the irrigated plots. The nitrogen is higher, but as the samples were taken in November, this is most probably due to the dry season accumulation of nitrogen, and also to the build up of organic matter under fallow.

Comparative data on nutrient status under dryland cropping was obtained by studying soils from rotation plots at Makanga. The treatments involved are Cotton (C), Fallow (F), Groundnuts (G), Legume (L), Maize (M), and Maize+10 tons Khola Manure (MK). The means of four plots are given below:

1957/58	58/59	59/60	Org. carbon	N	P	K	pH
C	G	M	2.17	.158	1,440	1.68	6.7
C	G	MK	2.29	.173	1,278	3.18	6.5
C	G	M	2.25	.183	1,254	1.88	6.6
F	F	F	2.49	.193	1,441	3.68	6.9
G	M	C	2.32	.175	1,546	1.76	6.8
G	MK	C	2.14	.155	1,404	2.02	6.8
G	M	F	2.42	.168	1,564	1.95	6.8
F	F	C	2.52	.185	1,569	2.21	6.7
M	C	G	2.33	.184	1,562	1.69	6.7
MK	C	G	2.24	.166	2,019	3.41	6.6
M	F	F	2.37	.169	1,555	1.63	6.7
F	C	G	2.27	.169	1,651	1.71	6.6
C	C	C	2.54	.177	1,704	1.80	6.8
M	M	M	2.15	.158	1,564	1.60	6.7
C	M	M	2.31	.158	1,678	1.85	6.7
M	C	C	2.38	.155	1,706	1.75	6.7
C	L	L	2.30	.165	1,572	1.95	6.7
L	M	M	2.38	.168	1,557	1.75	6.7
M	C	C	2.33	.163	1,538	1.90	6.7

It is seen again that there is little difference in the nutrient content of these soils, except that where khola manure has been added, there is a marked increase in available potassium. As these samples were taken about a year after the manure had been applied, this may explain why there is no similar increase in the organic matter content of the soils. On the other hand, it may be that the acidity of the manure releases more potassium. The lower pH of the plot on which khola manure was most recently applied may be noted in this connection.

The fallow plots also have a higher content of potassium, as well as organic matter and nitrogen. Where groundnuts are included in the rotation, the nitrogen level tends to be rather higher but not significantly so.

It is clear that this cycle of rotations will have to continue for many years before any marked differences can be detected.

REPORT OF THE AGRICULTURAL CHEMIST, CHITEDZE

Village Garden Soil Survey (Central Province)

The object of this work has been to obtain more detailed information with regard to the fertility level in ordinary trust land gardens, and in particular to see what relationship if any, there was between this and the progressive deterioration in the quality of dark fired tobacco which has taken place over the last ten years.

Preliminary Survey—September/October, 1960

This was carried out in six tobacco market areas within the Lilongwe District when 240 garden soils from 37 villages were chemically analysed. From the resulting data it became apparent that on a large number of these gardens it was the low level of available phosphate which was probably responsible for the poor fertility observed in many cases, and which could well be affecting tobacco quality and yield. It was recommended therefore that the study be extended during the 1961 dry season to include all market areas in Lilongwe and other districts of the Central Province, with a view to assessing the extent of the low phosphate soils, in order that a fertilizer incorporating superphosphate could be applied where necessary in the 1961/62 growing season.

Full Scale Survey—July/September, 1961

Approximately 3,500 samples representing 17,500 growers (i.e. five growers' gardens per composite sample) from 1,700 villages in 20 market areas, were examined over a ten-week period for pH, texture, available phosphate and potash. In addition some 1,500 nitrogen and organic determinations were carried out on selected soils as well as phosphate reserves on all soils which had 8 p.p.m. or less available phosphate.

Available phosphate was determined by extracting 2.85 g. of soil for one minute with 20 ml. of 0.03 N NH_4F in 0.025 N HCL (Bray's No. 1 solution). Reserve phosphates were determined similarly only the extractant used was 0.03 N NH_4F in 0.1 N HCL (Bray's No. 2 solution). These are the standard methods in use for soils of the area and have previously been found to relate satisfactorily with fertilizer responses under controlled experimental conditions.

On completion of the examination fertilizer recommendations were prepared for each village within a particular market area, a list being sent to each market concerned. These were based primarily on whether a specific soil required either a mixed fertilizer combining sulphate of ammonia and superphosphate (a 10:9:0 mixture was specially prepared) or sulphate of ammonia only. The basic recommended rate of the former was 300 lb./acre, while the latter was 200 lb./acre. Variations in texture and acidity were however taken into account and recommendations were adjusted where necessary.

Results

These have shown that the large majority of gardens are situated on moderately to slightly acid sandy loams or sandy clay loams with the latter greatly predominating. Nitrogen status is closely related to texture, supplies being from low to medium in the loamy sands and sandy loams and from medium to adequate on the sandy clay loams and sandy clays. By and large potash supplies, as previously anticipated are satisfactory mainly ranging from medium to adequate.

An average of around 70 per cent. of the soils examined contained 8 p.p.m. or less of available phosphate, this being in the range low to very low. In many others supplies were at the medium level (9-15 p.p.m.) and it is anticipated that the status of many of these will become marginal with further cropping. In no case however was a recommendation for additional phosphate made where a soil had more than 8 p.p.m. available P or 15 p.p.m. reserve P.

It is of interest to note that generally speaking it is in the heavier textured soils i.e. sandy clay loams, sandy clays, that the low phosphate levels occur. These are those on which the greater part of all cultivation takes place, with the possible exception of the Kasungu area, and this may explain the depletion of supplies on these soils. That this can occur fairly rapidly even under good farming conditions has been well illustrated at Chitedze when the phosphate level on these textural groups has fallen markedly during the last few years, and where significant responses to phosphate application are now being obtained.

Table I summarizes some of the results just discussed.

These results have provided sufficient information to allow simple tobacco demonstration plots to be laid out on selected village gardens low in phosphate, throughout the Lilongwe District during the coming season.

The exercise has also proved to be extremely useful as a means of rapidly assessing the nutrient status of considerable areas of land and would probably be of great value in helping to estimate the productivity potential of soils within agroecological zones.

The Release of Nitrate Nitrogen, Chitedze

During the past twelve months a simple study of the soil nitrate nitrogen release has been in progress at Chitedze. Composite soil samples (six replicates per sample) have been taken at weekly intervals from 0-9 inches within the ridges of a bare fallow plot in field C Zero, and the amount of free nitrate nitrogen present in each, determined in the laboratory. The plot has been kept clean weeded throughout.

The data obtained is presented graphically in Fig. 1. This confirms the work of Birch and Friend in East Africa, in showing the very considerable release that occurs over approximately a three week period after the soil has dried out, and is then rewetted at the onset of the rains. Provided the soil remains moist after the first release of nitrate nitrogen no marked build up occurs, and it must then dry out for an appreciable time before a further marked release is obtained on rewetting. The value of this release to the early planted crop is clearly demonstrated.

TABLE I
Summary of pH, Texture and Available Phosphate data—Village Garden Survey, 1961
(Results expressed as Percentages throughout)

District	Degree of Acidity (pH)					Texture					Avail. Phosphate p.p.m.	
	str. acid 4.8-5.3	acid 5.4-5.7	mod. acid 5.8-6.0	slt. acid 6.1-6.5	v. slt. acid 6.6-7.0+	sand	loamy sand	sandy loam	sandy cl. loam	sandy clay	8 or less	> 8
Lilongwe 12 markets—2,083 samples	1.0	18.1	52.9	26.1	1.9	0.1	1.9	14.3	78.1	5.6	69.1	30.9
Dowa 4 markets—904 samples . .	1.2	16.1	57.1	24.4	1.2	0.3	1.8	17.2	73.6	7.1	81.0	19.0
Dedza 1 market—70 samples . .	Nil	5.8	68.2	24.6	1.4	1.5	1.5	7.5	70.1	19.4	45.7	54.3
Fort Manning 1 market—80 samples . .	1.3	42.3	36.3	18.8	1.3	1.3	1.3	27.4	65.0	5.0	32.5	67.5
Kasungu 1 market—140 samples . .	0.7	3.6	35.8	51.1	8.8	0.7	10.9	55.6	32.1	0.7	52.1	47.9
Kota Kota 1 market—190 samples . .	0.5	13.7	27.9	46.3	11.6	Nil	Nil	21.8	72.8	6.1	42.1	57.9

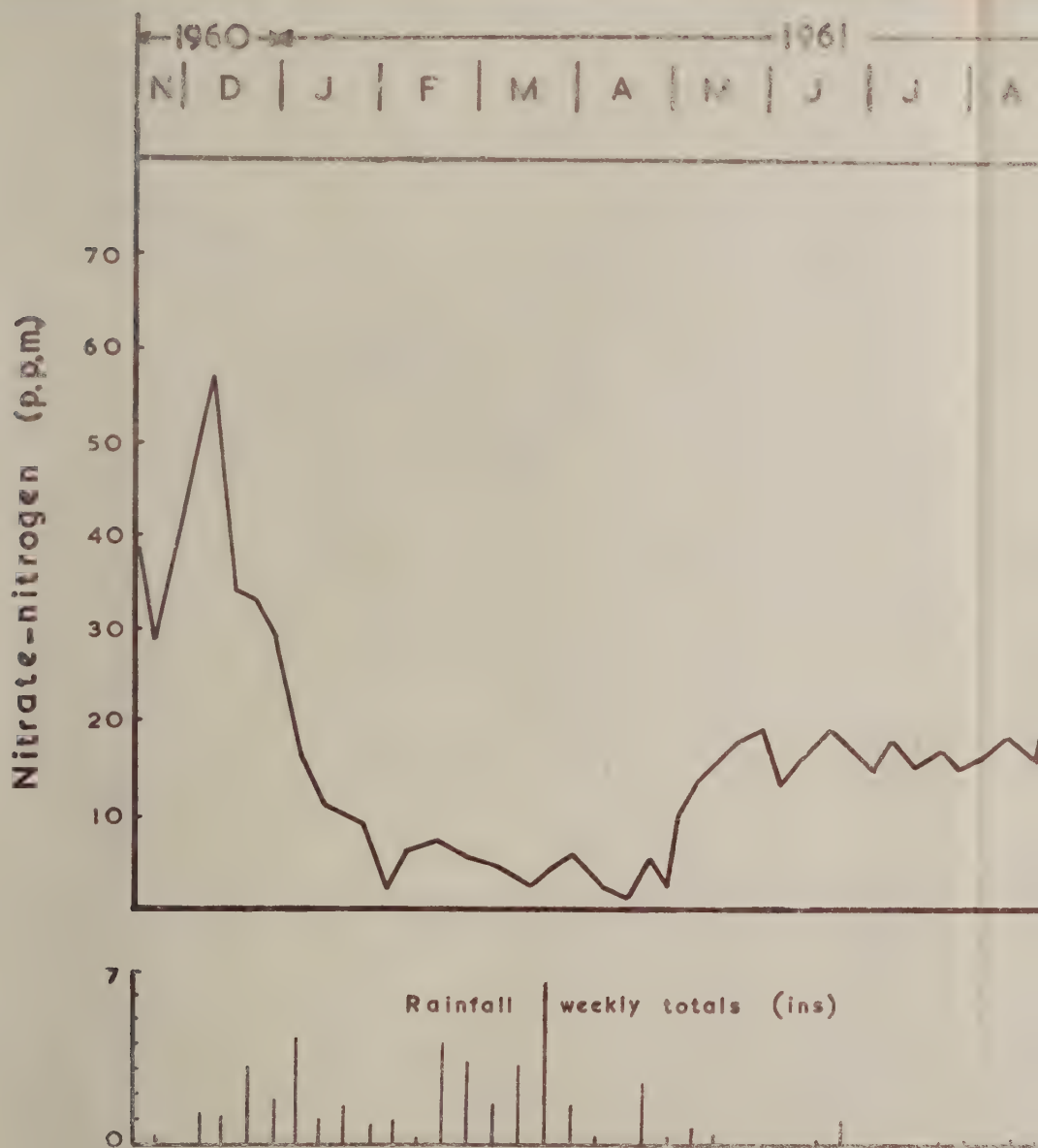


FIG. 1. Seasonal nitrate-nitrogen release,

THE REPORT OF THE PLANT PATHOLOGIST

Potatoes

During the year under review, late blight of potatoes, caused by *Phytophthora infestans* (Mont) de Bary, has been less serious than in either of the two seasons since its advent in January, 1959. The reason for this is not known. In the absence of full meteorological data from the main potato growing areas, conjecture on this point is valueless.

Tomatoes

With the advent of Late Blight (*Phytophthora infestans* (Mont) de Bary) on tomatoes, it is necessary to find some form of fungicidal control. An experiment was laid out in Zomba in order to test 4 fungicides and two methods of timing applications: spraying weekly and spraying after every 2 inches rain. The experiment, a randomized block with plots split 8 times for varieties in order to give some idea of the performance of varieties, yielded the following results:

TABLE

Treatment	Thiram 2 lb./ 115 gals.		Cuprous oxide 7 lb./ 115 gals.		Zineb 2 lb./ 115 gals.		Captan 2 lb./ 115 gals.		Control
	Weekly	After 2 ins.	Weekly	After 2 ins.	Weekly	After 2 ins.	Weekly	After 2 ins.	
Yield in tons/acre	4.90	4.43	6.57	5.69	5.49	5.37	5.69	6.45	3.92

Sig. dif. 5% = 0.80

Sig. dif. 10% = 1.08

Coef. var. = 13.3%

All treatments except Thiram after every 2 inches rain were significantly better than the control at the 5 per cent. level, with cuprous oxide weekly and Captan after every 2 inches rain very much better than any other treatments. Sixteen weekly sprays were applied, while those plots sprayed after every 2 inches of rain were sprayed 8 times.

Although the rainy season in which this experiment was held was wetter and longer than the two previous ones, Late Blight did not appear until 6 weeks after planting out the seedlings and never became epidemic. The main development of the disease was on the fruits, little leaf loss being caused. The main leaf pathogen was *Septeria lycopersici*, which first appeared in the seedbed and developed to a considerable extent in the field.

Alternaria solani and *Cladosporium fulvum* were also present, but caused no appreciable damage.

Observations subsequently made indicated that Late Blight developed very severely on tomatoes in June, during the winter. At this time of the year the nights are clear, and a heavy dew fall occurs maintaining a surface film of water on leaves from late evening until at least an hour after sunrise, a period of between 12 and 13 hours.

Notes on other diseases will be found under the appropriate Crop Sections:
Bullrush millet p. 38; Cacao p. 164; Groundnuts p. 46.

New Records

The following new records on cultivated crops were made during the year.

Allium cepa—Onion:

Purple blotch: *Alternaria porri* (Ell.) Cif.

Apium graveolens—Celery:

Late Blight: *Septoria apii* Chesters.

Arachis hypogea—Groundnut:

Leafspot: *Phoma* sp.

Leafspot: *Peyronellaea glomerata* (Corda) G. Goid.

Carica papaya—Pawpaw:

Mildew: *Leveillula taurica* (Lev.) Arn.

Chrysanthemum hortorum—Florist's Chrysanthemum:

Leaf blight: *Septoria* sp.

Rust: *Puccinia chrysanthemi* Roze.

"Petal" blight: *Phyllosticta* sp.

Citrus reticulata—Naartje:

Blue mould: *Penicillium italicum* Wehmer.

Cyamopsis psoralioides—Guar:

Leafspot: *Phoma* sp.

Leafspot: *Alternaria macrospora* Zimm.

Delphinium ajacis—Larkspur:

Leafspot: *Cercospora* sp. nr. *canescens*.

Fragaria vesca—Strawberry:

Leafspot: *Cercospora vexans* Massal.

Gerbera jamesonii—Barberton daisy:

Leafspot: *Cercospora gerberae* Chupp & Viegas.

Glycine max—Soya bean:

Leafspot: *Cercospora canescens* Ell. & Mart.

Leafspot: *Mycosphaerella phaseolorum* Siemaszko.

Luffa cylindrica—Loofah:

Leafspot: *Cercospora citrullina* Cooke.

Musa sp.—Banana:

Fruit rot: *Macrophoma* sp.

Nicotiana tabacum var *Turkish*—Turkish tobacco:

Leafspot: *Xanthomonas* sp.

Oryza sativa—Rice:

Glume blotch: *Verticillium* sp.

Pelargonium zonale—Geranium:

Leafspot: *Cercospora* sp. nr. *canescens*.

Pennisetum purpureum—Napier fodder:

Leafspot: *Cercospora fusimaculans* Atk.

Persea americana—Avocado pear:

Algal leafspot: *Cephaleuros pulvinatus* Schmidle.

Phaseolus vulgaris—French bean:

Leafspot: *Periconia byssoides* Pers ex Schew.

Leafspot: *Mycosphaerella pinodes* (Berk & Blox) Vestergr.

Leafspot: *Colletotrichum* sp.

Plumeria sp.—Frangipani:

Leafspot: *Cercospora* sp.

Saccharum sp.—Sugar cane:

Sheath Spot: *Hyalostachybotrys sacchari* Srinavasan.

Red rot: *Glomerella tucumanensis* (Speg) Arx & Muller.

Pineapple disease: *Ceratocystis paradoxa* (Dade) Morean.

Rind disease: *Pleocyta sacchari* (Mass) Pet & Syd.

Ratoon stunting disease: Ratoon stunting virus.

Solanum melongena—Egg fruit:

Leafspot: *Ramulispora sorghicola* Harris.

Tecoma stans:

Root rot: *Armillaria mellea* (Vahl ex Fr.) Quel.

Theobroma cacao—Cocoa:

Leafspot: *Colletotrichum brachytrichum* Delacr.

Pod rot: *Botryodiplodia theobromae* Pat.

Pod rot: *Fusarium sambucinum* Fuckel.

Viola odorata—Violet:

Root rot: *Sclerotium rolfsii* Sacc.

Widdringtonia whytei—Mlanje cedar:

Root rot: *Armillaria mellea* (Vahl ex Fr.) Quel.

Acknowledgement

The Pathologist is greatly indebted to the Director and staff of the C.M.I. for continued help in the identification of specimens.

Annual, Report, Fusarium Scheme

All coffee growing areas were visited at one time or another in the course of the year, and opportunity was also taken of meeting the Plant Pathologist from Lyamungu Coffee Research Station, Tanganyika when he visited the Tanganyika Southern Highlands coffee areas. In all areas visited including Tanganyika, the complex of *Fusarium* bark diseases was found to be present and causing considerable damage. Specimens from Portuguese Milanje have also been examined, and the disease found to be present in them.

DEVELOPMENT OF THE DISEASE

The symptoms have been described fully before. In the year under review one further observation was made on the development of the disease.

Collar rot. The form of the disease described as collar rot has been found to develop from within the stump, the fungus having gained entry through suckers well above ground level and grown down to soil level in the bark. Once it reaches ground level, growth of the fungus around the stump girdled it, finally causing death.

IDENTITY OF THE FUNGUS CAUSING THE DISEASE

In the last year's annual report, it was stated that *Fusarium lateritium* Nees ex Fr. var *longum* Wr. (*F. stilboides* Wr. forma) had been shown to be associated with all

three forms of the disease, and inoculation tests had confirmed that this fungus did indeed cause the disease. It was thought at the time and partially confirmed, that the fungus from any one of the three forms of the disease could cause the other two. Final confirmation of this has now been obtained from three trials:

A. *Zomba inoculation trial.* In this trial, inoculum from each of the three forms of the disease was used, and inoculated to suckers after pricking with a sterile needle. This trial has confirmed Storey's bark disease can be caused by *F. stilboides* from both the Collar Rot and Scaly bark forms of the disease.

B. *N.T.E. trial.* This trial was designed to see if there was any relationship between disease incidence and pH of the soil. It was secondarily designed to see if inoculum from Storey's bark disease could cause the Scaly Bark form of the disease. Inoculum from diseased suckers was applied, in sterile water, to freshly cut snags left after pruning with sterile secateurs. Typical scaly bark symptoms were produced.

C. *Greenhouse trial.* In this trial, it was intended to show how wounding and deep planting affected production of the disease, and secondarily if Storey's bark disease inoculum could cause the Collar Rot form of the disease. Plants in pots in the Greenhouse were inoculated at soil level with inoculum obtained from Storey's bark disease. Typical Collar Rot symptoms were produced in those plants which were inoculated after wounding, and in no others.

It has thus been shown that Scaly Bark and Collar Rot can be caused by the fungus from Storey's bark disease, while Storey's bark disease can be caused by inoculum from Scaly Bark and Collar Rot. It is considered that this is sufficient evidence to assume that the three forms of the disease are merely different symptoms of expression of attack by the same organism, due to infection in different parts of the coffee plant.

PHYSIOLOGY OF *F. STILBOIDES* IN RELATION TO THE DISEASE

Further studies have been made of the behaviour of the fungus in relation to the disease.

(a) *Period of viability in soil*

F. stilboides can be isolated in soil in which a plant has died of collar rot. As the length of time the fungus can remain viable in soil has obvious implications where control is concerned, an experiment was set up to determine how long the fungus could remain viable in both sterile and normal unsterilized soil. Air dried soil was used to which was added water in a range including 5 per cent., 25 per cent., 50 per cent. and 100 per cent. (field capacity) inoculum consisted of a standard spore suspension. In sterile soil the fungus remained viable for only two months in the air dried soil, but was reisolated successfully from the rest of the series (5, 25, 50 and 100 per cent.) during the nine months the experiment ran. In the unsterilized coffee soil, the fungus was only successfully reisolated from the air dried soil, and 25 per cent. moisture soil at the end of the first month, and thereafter was not reisolated. This suggests that planting of coffee in a hole from which a plant killed by collar rot has been removed could be safely done two months after removal of the dead plant.

(b) *Period of viability in infected bark*

The longevity of the fungus in infected bark is of importance in control of the disease.

Infected bark samples were collected, and placed in brown paper bags in the laboratory. At 1, 2, 3, 5, 6 and 12 months after collection pieces of bark were removed and plated after surface sterilization. At the end of the 12 month period, *F. stilboides* was still isolated from the bark.

At the same time, inoculum from the bark was used to see if pathogenicity was retained during the same period. The inoculum was applied in sterile water to the fresh leaf scar left after removal of a leaf from a nine month old potted seedling. Successful infection occurred only with inoculum retained 1 2, 3 and 5 month: none occurred after retention for 6 to 12 months. This suggests that coffee prunings from diseased bushes are not safe until six months have elapsed after pruning, and therefore should be removed from the plantation.

(c) *Temperature relations of F. stilboides*

An experiment was designed to find out the optimum temperature for growth of *F. stilboides* in culture. The fungus was found to grow over a range from 15° to 30°C, with a well defined optimum at 25°C.

(d) *Spore production*

Laboratory work on the environmental factors associated with spore production is not yet complete, but some field observations have been made. In last year's Annual Report, it was stated that during the period May-September spore production is reduced considerably. Further observation shows that in September-October, the hottest and driest part of the year, spore production ceases, and attempted isolation of *F. stilboides* from old lesions is not generally successful. With the coming of rains, the disease spreads and the fungus may be found sporulating profusely and is easy to isolate from infected tissues.

CONTROL

(a) *Fungicidal control*

In order to test the efficiency of fungicides, 3 spraying trials were held on estates, two of them continued from the previous year. Two of the trials were abandoned without any results, as the estate owners uprooted the coffee being sprayed. The one remaining trial, held on Namabinzi Estate, Cholo (N.T.E.) was a trial to determine different spraying times, using Captan at 2 lb. 100 gals./acre. This trial has lasted over a year, and consisted of three spray regimes: weekly, biweekly and monthly with an unsprayed control. The only spray to give significant control was the weekly one.

A summary of this trial is presented in the table below.

Treatments	No. of Plants Sprayed	Infection				Total
		Aug-Dec 1960	Jan-Mar 1961	Apr-June 1961	July-Sep. 1961	
Weekly	128	5	5	7	11	28
Fortnightly	126	6	11	18	19	54
Monthly	127	7	14	15	22	58
Control	120	5	15	21	25	66

It is apparent from the foregoing that fungicidal control will not be economical, as the only control is obtained with once weekly spraying. No further spraying trials will therefore be instituted.

(b) *Resistant varieties*

Work on this aspect of control has been increased in the year under review. A large trial involving 30 different varieties has been carried out on 9 month old seedlings in polythene planting tubes in the green house. In this trial, plants were inoculated

by applying fresh inoculum in sterile water to fresh leaf scars made by removing one of the 3rd pair of leaves from the tip. Five seedlings were used of each variety. Resistance was assessed on growth of the lesion and whether or not the fungus reproduced on the lesion. Six months after inoculation, the following varieties are considered to show considerable resistance: S.L. 14, S.L. 34, Caturra, Dilla and Alghe. Fair resistance was shown by K. 7, N. 5, Brazil, K.P. 228, S.L. 6, K.P. 128, K.P. 423 and N. 81, while Geisha, Kent's Hybrid, Kenya Selected and local show moderate susceptibility. No firm recommendations can be made, however, until these tests are repeated in the field. An experiment to enable resistance in the field to be worked out has already been planted.

(c) *Grafting*

Coffea robusta has been shown to be completely resistant to the disease. It was thought therefore, that *C. robusta* would make a useful stock where collar rot in particular was severe. Experiments in grafting *arabica* seedlings to *robusta* have been successful, approach grafting showing the most success. There are no results to report yet of inoculations in this experiment.

ENTOMOLOGY

Stored Product Investigations

Investigations were continued. In the preliminary survey of pests of stored products commenced in November, 1960, 85 firms or separate premises of the same organization were visited at least once. Two forms were used in the survey, one recording the produce inspected, the degree of infestation found, the pests involved, the control measures taken and the general condition of both produce and warehouse. The second form recorded the types of produce dealt with by the firm, details of stores, sheds, warehouses, mills, etc. and their construction, where the produce was obtained, the turnover, how and where the produce was sold and other details of running the business or concern.

The table below shows the infestation during the course of this preliminary survey to September, 1961, at the time of the inspection:

<i>Firm dealing with</i>	<i>Infestation level</i>				<i>Totals premises inspected</i>
	<i>Severe</i>	<i>Moderate</i>	<i>Slight</i>	<i>Free</i>	
Tobacco	3	3	0	12	18
Mixed food produce	23	4	12	10	49
Seed cotton and cotton seed	2	0	1	0	3
Retailing foods	1	2	0	12	15
TOTALS	29	9	13	34	85

60 per cent. of the premises inspected were infested to some degree, therefore, and, apart from tobacco exporters, the premises of almost all the exporting firms were infested. Uninfested premises belonged to tobacco exporters, retail firms with small stocks and quick turn-overs, and to firms with empty stores at the time of the inspections. At some time of the year probably all firms dealing with food produce were seriously infested.

The investigations during the past year also showed:

1. All the exporting firms (excluding tobacco exporters) tended to purchase produce in excess of their storage capacity. This meant that during the season the warehouses, etc. were overloaded, produce was mixed, and some had to be stacked in the open in many cases. It usually resulted in chaotic conditions within a warehouse or shed and, since proper pest control was impossible under such conditions, a high degree of infestation by insects resulted.

2. Infested produce was often taken into sheds with other produce that had been fumigated previously, and then left without fumigation for perhaps weeks or months, with a result that the previously fumigated produce became reinfested. Conversely, a stack was sometimes fumigated with adjacent unfumigated and highly infested stacks, and the fumigated stack left for several weeks with cross-infestation resulting.

3. While some firms took some pest precautions, others took none. Of those firms taking control measures, with the exception again of the larger tobacco exporters, the measures taken were often not adequate, or were unsuited to their particular problems. In one or two instances there was excessive use of insecticides due to misplaced zeal, creating a possible hazard to the consumer.

4. The use of methyl bromide by untrained people with inadequate equipment increased (and is still increasing) with a result that (a) fumigation is unsatisfactory and only a partial kill is obtained on many occasions; (b) there is a considerable hazard to human beings resulting from the use of poor or inadequate sheets, lack of warning notices, no detector devices and sometimes no gas-masks, and wrong dosages.

5. The fourteen known firms exporting food produce from this country have numerous sub-agents throughout Southern and Central Provinces, some of whom undertake to fumigate the produce purchased. Many of these sub-agents have no proper facilities and handle the produce in garages, small stores in yards in the open, on verandas or even in rooms of houses.

6. A considerable tonnage of maize and cassava came from Mozambique through Nyasaland by road to Balaka or Luchenza railway stations. This produce was never fumigated and was invariably found infested, usually heavily. Most of this produce was consigned to Dondo and Sena. It was stored at Balaka and Luchenza often for some weeks while awaiting transport and seriously infested the transit sheds and railway trucks. Infested groundnuts also arrived from Northern Rhodesia but arrangements have now been made for these to be fumigated.

During the year, due to advice on pest control and the increased inspection of produce, a considerable improvement has been noted, but it is only by frequent inspections that this improvement can be maintained. Commercial firms have shown considerable interest and willingness to co-operate in our endeavours to improve the situation, but smaller firms are often handicapped by lack of funds and storage space. The general standard of cleanliness has improved and some firms have already started to extend their premises to provide better storage facilities.

A booklet "Insect Pests of Stored Products in Nyasaland" has been produced describing the major pests and their control, and this will be available shortly to the general public.

Zomba Insect Collections

The collection of Coleoptera has been completely reorganized this year, and 188 identified species or genera new to the collection have been incorporated, mostly from the Lower River collection. The total dry collection of Coleoptera at present consists of representatives of 55 families and over 650 identified species. Many other species have not been identified yet and remain to be incorporated.

The collections of Hemiptera and Lepidoptera have been partly reorganized and classified. More than 30 families and some 250 identified species of Hemiptera, and 46 families and 430 identified species of Lepidoptera, make up the main collection of these two orders.

Notes on Pests

Recorded inquiries on insect pests and other arthropods numbered 92. Numerous minor inquiries were not recorded.

Icerya purchasi was recorded several times during the season, chiefly on roses, but it was nowhere serious. *Orthezia insignis* was less numerous than last season although still locally severe in some gardens on such major hosts as *Lantana*. It was recorded on *Albizzia* sp. for the first time (Blantyre).

Laphygma exempta Wlk. swarms on grasses and lawns were reported and identified from Zomba, Limbe, Mbawa, Dedza, Chitedze (attacking Rhodes Grass) and other centres in April and May, but the caterpillars disappeared by June in most areas. It is most unusual for the active, gregarious phase of Armyworm to be seen as late in the year as this, swarms being found normally in January and February. The unusually heavy and prolonged rainfall late in the season is thought to be the chief factor responsible, and the relatively lush growth of vegetation probably enabled a generation of active phase larvae to be produced in many areas instead of the normal passive phase.

One swarm of active phase larvae of *L. exigua* Hb. was recorded in Zomba in April.

Plusia chalcites Esp. larvae were recorded attacking Russian Comfrey at Chitedze in February. The larvae were reared in Zomba and this is the first record of this moth on this host. *Zonocerus elegans* attacked the same host.

Popilla bipunctata F. and *P. breanii* Kolbe were recorded in several areas attacking garden roses in April.

Oleuthreutes leucotreta, the False Codling Moth, was recorded from oranges in three localities.

Helopeltis? *schoutedeni* Reut. caused considerable damage to *Capsicum* spp. at Malosa this season in June and July. This is the first record on this host, and *Helopeltis* was also recorded from guava and cashew for the first time this season.

Systates sp., *S. smeei* and *Hipperhinus* sp. specimens were received from the Forestry Department and recorded as attacking Mlanje Cedar (*Widdringtonia whytei*) on Mlanje Mountain.

Local but severe damage to *Cupressus lindleyi* in Luwawa Forest, N. Province, was reported by the Forestry Department. The leading shoots of many young plants were eaten in October. The larvae received belonged to the family Lasiocampidae, and two of these eventually pupated in Zomba after rearing on *C. lindleyi* leaves. One emerged (the other has yet to emerge at the time of writing), the pupation period being 37 days. The adult was identified by the Commonwealth Institute of Entomology as *Bombycopsis venata* Butler, a species hitherto unrecorded from this country.

In Mingoli Forest, Zomba, a species of weevil, tentatively assigned to the genus *Opseodes* at the British Museum and unrepresented in the collection of that institution, was reported by the Forestry Department as defoliating *Eucalyptus tereticornis*.

An *Aspidiotus* sp. (Diaspididae) was found commonly on coconuts at Fort Johnston. Although this scale was numerous, chiefly on the nuts, little damage appeared to have been done, and only a small percentage of the insects were alive on samples taken. The scale is kept under control by various natural enemies.

Notes on other pests will be found under the appropriate Crop Sections: Other Cereals, p. 40; Oil Seeds, p. 46; Tobacco, p. 64; Cotton, p. 71; Tea, p. 133; Coffee, p. 157; and Cocoa, p. 165.

MACHINERY FOR SMALL-HOLDERS

Over the last three years experiments have been conducted on the percentage of breakage and damage occurring in groundnuts of differing variety when put through the types of small hand shelling machine at present offered on the market. These fall into two main categories:

(a) The fixed screen moving shoe sheller, of which the Skylux senior, Lepe and Senafric machines are very similar representatives;

(b) The fixed shoe, moving screen or "rocker" type, of which the Skylux Junior machine is at present the only representative tried.

In the first category all three makes gave very similar results, and experiments have as a result been confined of late to the Skylux Senior as being the representative of this type.

Four screen sizes were tested. These are punched with slots of a standard 2 inch in length and a width varying as follows; 0.354 in., 0.375 in., 0.406 in. and 0.500 in. It was found necessary to alter the screen size to suit the different types of nut grown in Nyasaland as will be discussed below.

Two types of shoe were also tried out, but these made very little difference to the sample produced.

In nearly all experiments freshly harvested nuts were put through the machines, i.e. those harvested in the current season. Where nuts of the previous season were used, i.e. nuts which had been stored for 12 months or more, it was found that the testa was much more fragile and breakage and damage was higher than the figures given below.

In the earliest tests only three grades were sorted out, namely:

(a) Good nuts.

(b) Damaged nuts—i.e. broken testa, but not split in half.

(c) Split nuts.

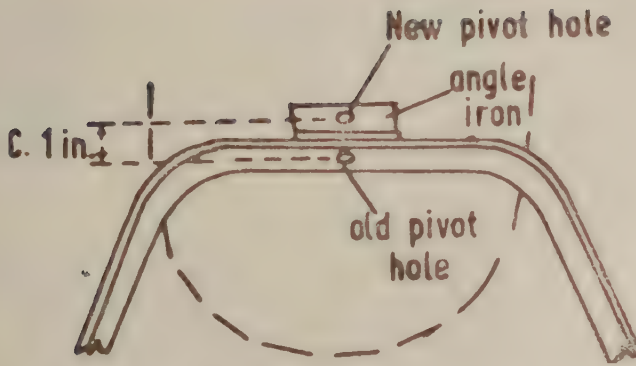
Category (a) contained a percentage of shrivelled nuts which were in later tests taken out, first by hand, and latterly by sieve, to form a fourth category.

(d) Shrivelled nuts.

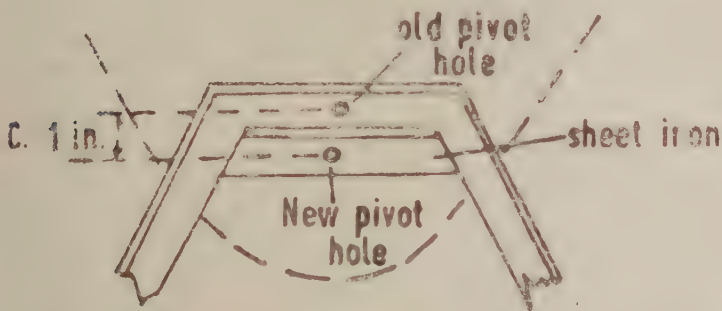
The percentage of nuts passing through unshelled was also recorded.

With the machines supplied by the maker, together with the range of screens and shoes, it was found possible to obtain samples of Valencia (Spanish) type nuts with about 12 per cent. split and damaged nuts, of Mwitunde, Chimbwila or Local type nuts with 40 per cent. split and damaged nuts and Chalimbana type nuts with 45 per cent. split and damaged nuts. Better results could not be obtained until the machines were modified to give greater clearance between shoe and screen than existing adjustments allowed. This modification was carried out as follows:

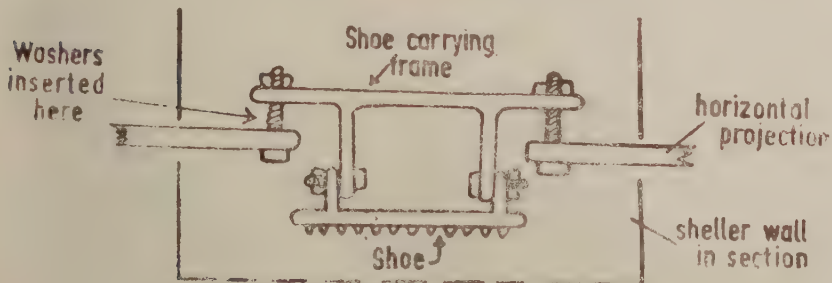
(1) *Skylux Senior*. Small bits of angle iron were welded onto the top of the supporting frame just above the maker's pivot holes, and new pivot holes were drilled through this about one inch above the old ones.



(2) *Skylux Junior old model.* Small bits of sheet iron were welded onto the supporting frame *below* the maker's pivot holes, and new pivot holes were drilled through this about one inch *below* the old ones.



(3) *Skylux Junior present model.* This, very conveniently, has its three fixed shoes carried on a frame which bolts onto and above two horizontal projections, one from each side. This gives almost infinite adjustment by inserting washers between the shoe carrying frame and the horizontal projections.



The adjustment on the Junior machines is more effective than on the Senior ones because the shoes occupy a smaller arc and the screens are not hemispherical. With the Senior machine the clearance at the bottom of the screen is enlarged but not that at the sides, and for the best results the two outside shoes ought also to be removed from the shoe holder. The improvement made by the adjustment was considerable and it would be worth the while of the manufacturer to alter the design of the Senior machine to allow for this much greater variation in shoe screen clearance, just as the Junior machine has been so altered.

TABLE I
Results of Shelling Trials with Skylux Shelling Machines

Variety of Nut	Machine	Screen size	Sieve size	Good nuts %	Damaged nuts %	Split nuts %	Shrivelled nuts %	Unshelled nuts %
A.R.S. Spanish or Valencia type	Skylux Senior unmodified	.354"	hand selected	82.2*	16.8	1.5	* Not separated	Nil
	Lepe	.354"	hand selected	72.0	10.3	5.9	11.8	Nil
	Skylux Senior modified	.354"	15/64"	91.4	2.9	.7	5.0	Nil
	Skylux Senior modified	.375"	15/64"	88.8	4.8	1.1	6.0	Nil
	Skylux Junior unmodified	.354"	hand selected	76.9	8.8	3.8	10.3	Nil
	Skylux Junior modified	.354"	15/64"	94.9	1.8	.8	3.0	.1
	Skylux Junior modified	.375"	15/64"	90.0	3.9	1.2	4.8	1.4
Mwitunde or Local types	Skylux Senior unmodified	.375"	hand selected	41.5*	27.9	30.6	* Not separated	.5
	Lepe	.375"	hand selected	46.8	15.6	27.7	14.9	Nil
	Skylux Senior modified	.375"	17/64"	74.7	7.3	7.8	10.1	.8
	Skylux Junior unmodified	.375"	hand selected	48.2	12.5	27.1	12.0	1.0
	Skylux Junior modified	.354"	17/64"	77.2	8.5	5.7	8.5	1.0
	Skylux Junior modified	.375"	17/64"	73.7	8.9	10.3	7.0	5.1
Early Runner	Skylux Junior unmodified	.375"	hand selected	57.7	7.7	6.1	29.9	2.7
	Skylux Senior modified	.375"	17/64"	74.6	4.9	1.0	18.6	3.1
	Skylux Junior modified	.375"	17/64"	73.0	9.8	.7	16.5	4.6
	Skylux Junior modified	.354"	17/64"	76.2	8.9	1.4	18.3	3.7
Dixie Runner	Skylux Junior unmodified	.375"	hand selected	81.3	31.3	24.0	13.4	6.0
	Skylux Senior modified	.375"	17/64"	57.6	16.0	10.7	15.7	7.3
	Skylux Junior modified	.375"	17/64"	64.6	16.7	7.6	11.0	13.2
	Skylux Junior modified	.354"	17/64"	67.0	11.5	8.1	13.4	7.1
Mani Pintar	Skylux Junior modified	.406"	17/64"	68.4	8.0	7.1	16.5	1.2
	Skylux Junior modified	.500"	17/64"	75.0	16.3	7.1	1.5	31.8
Jumbo types	Skylux Junior unmodified	.500"	hand selected	50.7	22.5	22.5	4.2	Nil
Chalimbana	Skylux Junior modified	.500"	17/64"	79.7	11.3	4.0	5.1	7.9
Arnand	Skylux Junior modified	.500"	17/64"	82.8	7.0	2.5	7.5	3.4

From the above table it is evident that plenty of clearance (1-2 inches) is required between shoes and screen. It is also evident that different varieties require different screens for best results. Gambia and Natal Common types (not given here) definitely require the .354 screen. Valencia or "Spanish" types have a wide tolerance and will be shelled equally well through a .354 or .375 screen. Local runner nuts and similar types, such as Mwitunde, Early Runner and Dixie Runner may be put

through either the 0.354 or 0.375 screen, though more damage occurs in these than in the Valencia types. Mani Pintar requires the 0.406 screen, and the Jumbo nuts require the 0.500 screen.

The sieves used for separating the shrivelled nuts were home made, slots being punched in aluminium sheet with a uniform length of $\frac{3}{4}$ inch and a width of 15/64, 17/64 or 19/64 of an inch. Even the smallest of these sieves will take off the split nuts quite easily, but they may take out of the sample small mature nuts as well as the shrivelled ones. For an optimum commercial sample a sieve 2/64 smaller than the one indicated in the table above would probably be good enough, so reducing the percentage of "shrivelled" nuts. The commercial sample consists of the "good" and "damaged" nuts, and with present techniques would constitute 80-95 per cent. of the crop depending on season and variety.

For the purposes of arriving at and improving on a figure for throughput of Mwitunde and Spanish nuts, the process was divided into shelling, winnowing and sieving. Of these the most time consuming job was shelling (provided that hand picking of the final sample is not required). Winnowing with a Skylux winnowing machine was effective but not all that much faster than hand winnowing, and of course the capital outlay was considerable.

A minimum team of two is required for machine shelling, but a team of four is probably better, of which two operate the sheller continuously and the other two winnow, sieve and feed the sheller by turns. Table II below gives the times taken for a two man team to produce a "commercial" sample from duplicate samples of 100 lb. unshelled nuts and from one 300 lb. sample of unshelled Mwitunde.

TABLE II
Time taken in various Machine Shelling Operations
(A two man team working throughout)

Machine and Screen	Variety	Sample unshelled lb.	Time taken in minutes				Saleable nuts produced lb.	Rate per hour	
			Shelling	Machine winnow	Sieve	Total		Unshelled lb.	Shelled lb.
Skylux Senior .375 ..	Spanish Mwitunde	100 100	25 34	16 21	9 9	50 64	65 52	120 95	75 50
Skylux Junior .375 ..	Spanish Mwitunde	100 100	37 65	20 30	8 10	65 105	61 53	90 65	55 30
Skylux Junior .406 ..	Mani Pintar	100	57	21	8	86	55	70	40
Skylux Junior .500 ..	Chalimbana Amani	50 100	25 30	10 10	6 12	41 52	25 62	70 115	35 70
Skylux Junior .375 ..	Mwitunde	300	215	32	25	272	156	65	35

From this it appears that the rate of working varies quite widely depending upon the variety being shelled. It appears also that the throughput with the Senior machine is about half as much again as that of the Junior one, though the quality of the work done is not quite as good. It should be possible for two men to produce between 250 and 350 lb. of shelled commercial sample per day with the Junior machine and from 350 to 500 lb. per day with the Senior machine.

It is estimated that one man cannot produce much more than 10 lb. of shelled nuts per day when doing it by hand.

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